Morphometric data on Cavoliniidae, with notes on a new form of Cuvierina columnella (Rang, 1827) (Gastropoda, Pteropoda)

by

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INTRODUCTION

Maximum and minimum size of pteropod shells are usually the only size data referred to in literature. In some species pronounced variation is known; data on size variation based on larger samples are, however, rarely published. In the present paper a description of the variation in length and width of some species is given. Two problems are separately discussed, viz., the size differences between various populations and the variation shown by specimens within one population. The smaller and larger forms found in the formae typicae of *Cavolinia longirostris* (Blainville, 1821) and *Cuvierina columnella* (Rang, 1827) are also discussed. Length and width have been taken from the shell in ventral view; in *Clio* species only the shells were measured when in reverse position, while species of the genus *Creseis* were studied in lateral view.

All specimens have been measured with an ocular micrometer in a Wild binocular dissecting microscope; an accuracy of 0.1 mm with low magnification and 0.02 mm with high magnification has been obtained. The material discussed was chiefly collected by the Dana Expedition. The stations of this expedition are given in the captions of the figures. Data from material of the Cirrus Expeditions and the Ocean Acre Project are occasionally used.

The author is very grateful to Drs H. Lemche and J. Knudsen for the opportunity to investigate the pteropods of the Dana Expedition, and to Dr. C.F.E. Roper for the opportunity to study the pteropods of the Ocean Acre Project. The author also owes a debt of gratitude to Prof. Dr. H. Boschma for critically reading and commenting on the manuscript in its initial shape.

GENERAL EXPLANATION TO THE FIGURES

The axis on which shell width is given in mm is indicated by W, the axis on which shell length is given in mm is indicated by L, the axis on which shell thickness is given in mm is indicated by T, the axis on which the number of specimens of the histograms is given is indicated by E. In figs. 1-5, and 12 latitudes are given on the vertical, shell length on the horizontal axis. The letters J, S, M, and A stand for juveniles, skinny stages, minute stages, and adults respectively, unless otherwise indicated. Data for juveniles are dotted, those for minutes white, and those for adults black in figs. 7, 10, 14, 23, 35, and 39.

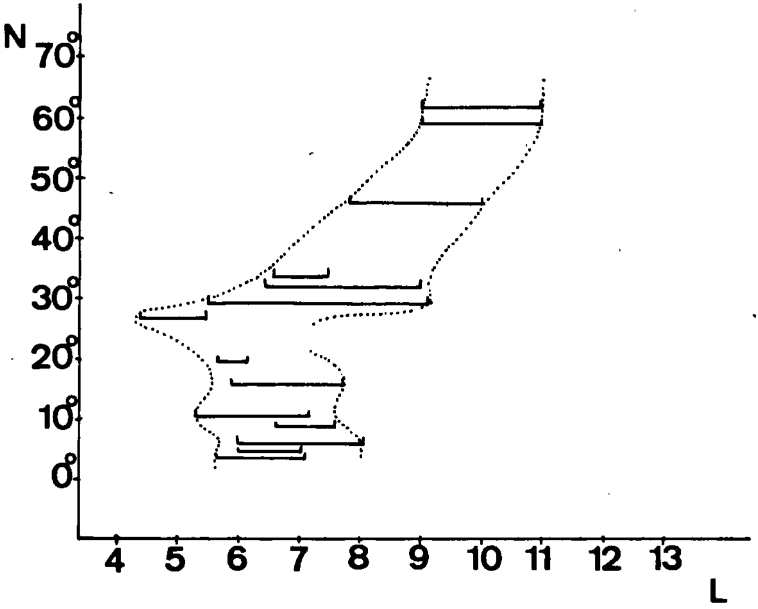


Fig. 1. Diagram of variation in shell length in populations of *Diacria trispinosa* forma *trispinosa* from the North Atlantic.

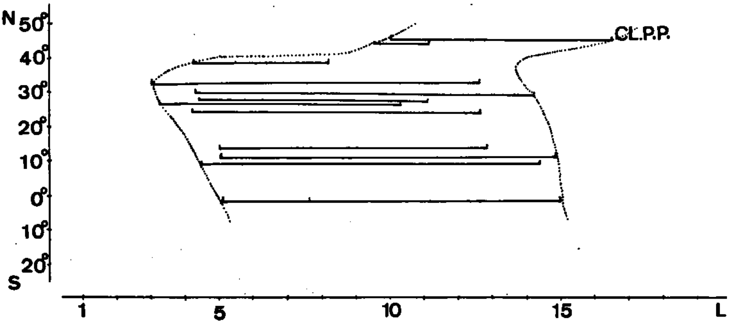


Fig. 2. Diagram of variation in shell length in populations of *Clio pyramidata* forma *lanceolata* and forma *pyramidata* (CL.P.P.).

VARIATION BETWEEN POPULATIONS

Diacria trispinosa (Blainville, 1821) forma *trispinosa* (Blainville, 1821) is one of the few pteropods with a very wide north-south range in the Atlantic Ocean and as such it has been selected here to show the differences between populations living at different latitudes (fig. 1). The shell length is chosen to measure the growth of the shell and to indicate the floating capacity (Van der Spoel, 1968b, 1969c).

Populations living at the highest latitudes consist of the largest specimens, which are as large as tropical specimens of the closely related and larger forma *major* (Boas, 1886). Near 30°N the populations of the forma typica are composed of the smallest specimens, while in tropical waters specimens of an average size are found. Size is dependent on growth and, as a consequence, on the fertility of the habitat. On the other hand there is a relation between the maximum size of an aquatic organism and the specific gravity of the surrounding water. Between 60° and 70°N fertility of the water masses is high and the temperature is low, both essential factors for the development of large specimens because such factors are conducive to growth and floating capacity of the specimens. The low salinity in the northern regions may have a small negative influence on the increase of size because it does not favour the floating capacity of the specimens. In the tropics temperatures are high and salinity is rather low, two factors unfavourable for floating, but the fertility is

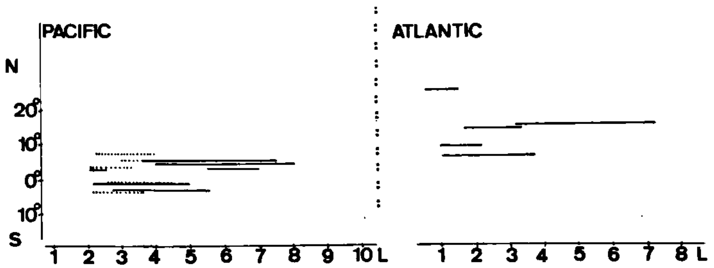
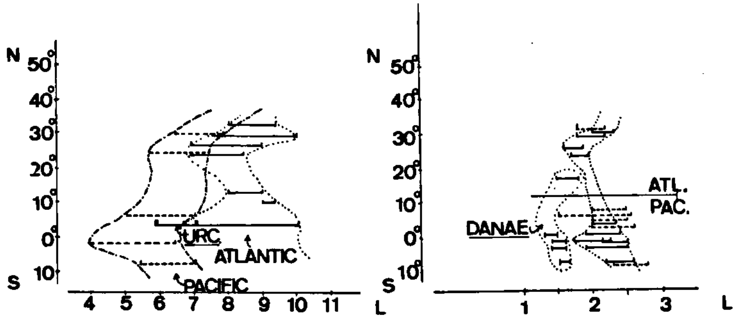


Fig. 3. Diagram of variation in shell length in populations of *Cavolinia longirostris* forma *longirostris* (solid lines) and forma *angulosa* (interrupted lines) in the Atlantic and Pacific Oceans.



Figs. 4-5. Diagrams of variation in shell length in populations of 4. (left) *Cuvierina columnella* in the Atlantic and Indo-Pacific Oceans; the forma *atlantica* (solid lines) from the Atlantic Ocean and the forma *columnella* (interrupted lines) from the Pacific Ocean. 5. (right) Do. of *Diacria quadridentata* forma *quadridentata* (interrupted lines), forma *orbignyi* (solid lines), and forma *danae* in the Atlantic (ATL) and Indo-Pacific (PAC) Oceans.

rather high so that specimens of an intermediate size occur here. In typically equatorial waters where tropical rains strongly lower the salinity, the decrease in specific gravity of the water results in small specimens. Near 30°N fertility is very low, temperature is still high and only the salinity is moderate so that in this area the stimulus to grow large is not very strong. Exactly the same tendency to grow larger at higher latitudes and to form only small shells in the area near 30°N is shown by *Clio pyramidata* Linnaeus, 1767 (fig. 2).

In *Cavolinia longirostris* there is also a tendency to form populations of larger specimens in the tropics and smaller ones near 30°N (fig. 3, right) (see also p. 122). These phenomena are also found in

Cuvierina columnella (Rang, 1827) forma *columnella* (Rang, 1827) (fig. 4) (see also p. 118) and *Diacria quadridentata* (Blainville, 1821) forma *orbignyi* (Souleyet, 1852) (fig. 5). The decrease in size of specimens in equatorial waters is not clearly visible in fig. 1, but evident in fig. 3 for *Cavolinia longirostris* and in fig. 4 for *Cuvierina columnella* forma *columnella*.

These differences between populations are dependent on ecological influences and not on accidental differences as demonstrated in figs. 31, 32, and 35. The populations of *Diacria quadridentata* forma *orbignyi* at 2°, 0° and 4°S, off West Sumatra and at 3°N, off North New Guinea, all show the same frequency distribution of shell-length and shell-width. The same is shown for *Cavolinia longirostris* forma *angulosa* (Gray, 1850) (figs. 38 and 39). These populations from different oceans, but from comparable latitudes, are nearly identical in regard to distribution of the size of the specimens. The differences in size of the specimens seems thus more dependent on latitudinally varying ecological influences than on other local influences, that is, when populations from the open ocean are considered. When discussing latitudinal variation, variation range and stability have to be considered (Pierrot-Bults, 1970). Stable environmental conditions such as those found in the tropics cause a reduction in the range of variation while less stable conditions at higher latitudes are considered to cause a greater variability. The data on size variation available at the moment do not give much information on changes in variability of the expected kind. In *Diacria trispinosa* forma *trispinosa* (fig. 1) the range of variation is small in the tropics, very wide near 30°N and moderate north of 40°N. In the other species discussed no clear indications on the diversity in the ranges of variation have been found. In most species and especially in *D. trispinosa* forma *trispinosa* the ecophenotypical range of variation seems to show a decrease when environmental conditions become less favourable and not when these conditions become more stable. Genetical ranges of variation may show the same tendency, but stability of the environment is of more importance here as it is the composition of the gene pool which is affected over long periods. In ecophenotypical variation the factor "time" is of small or no importance.

It is important to know the age composition of the examined material. Shell growth in Cavoliniidae has been discussed by Van der Spoel (1967, 1970a). There are three periods in life, viz., the juvenile stage, the minute or skinny stage (dependent on the species con-

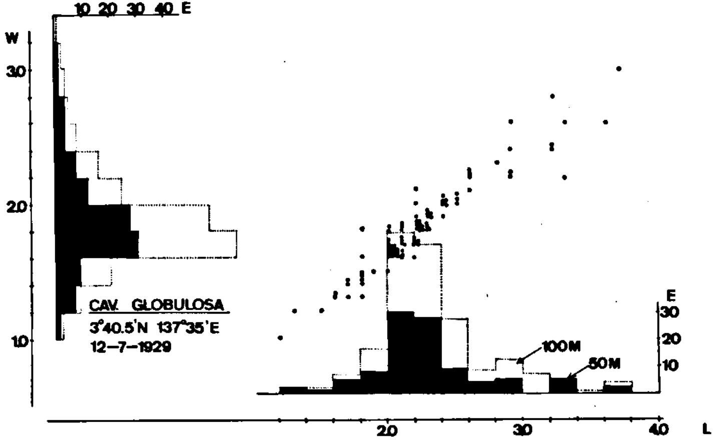


Fig. 6. Graph of shell length and width in juvenile *Cavolinia globulosa* (Dana Sta. 3751), collected at depths of 50 m (black) and 100 m (white).

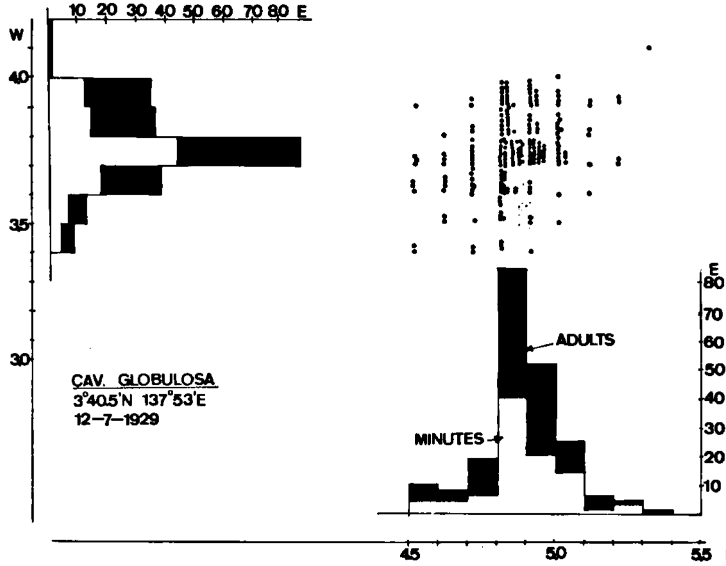


Fig. 7 Graph of shell length and width in *Cavolinia globulosa* (Dana Sta. 3751).

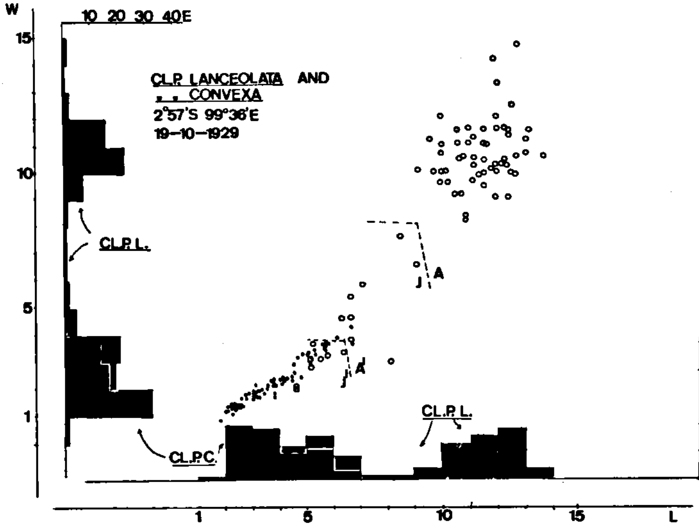


Fig. 8. Graph of shell length and width in *Clio pyramidata* forma *lanceolata* (CL.P.L., open circles) and forma *convexa* (CL.P.C., black circles) (Dana Sta. 3860).

cerned), and the adult stage, which periods are also reflected in the growth of the shell (fig. 11).

For *Cavolinia globulosa* (Gray, 1850) the size frequency distribution for the three stages in one population is given separately in figs. 6 and 7. Juvenile specimens regularly increase in length from 1 to 4 mm. The abruptly occurring metamorphosis (Van der Spoel, 967, 1968b) starts in the minute stage and stops when the pecimens have reached their final size; adult shells with mature soft parts show the same dimensions as the minutes (fig. 6). From the mentioned figures one may conclude (at least for *C. globulosa*) that size distribution (length and width of the shell) in a population is influenced by the presence of specimens of different ages when all stages are taken together; this is also demonstrated in figs. 8 and 9 for *Clio pyramidata* forma *convexa* (Boas, 1886). On the other hand, the presence of specimens of different age does not influence the size distribution when juveniles are excluded, and the minutes and adults are considered together as in fig. 7. When all age classes in a population are older than those at which metamorphosis starts there is usually only one length and width class, the adult size class. In

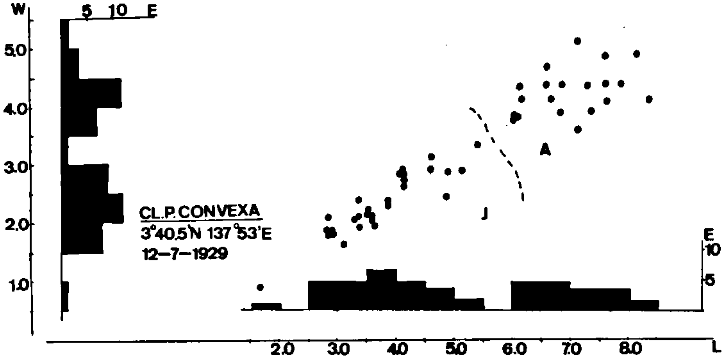


Fig. 9. Graph of shell length and width in *Clio pyramidata* forma *convexa* (Dana Sta. 3751).

most species growth does not continue after metamorphosis or it proceeds only for a short time and results in negligible size increase. *Cuvierina columnella* forms an exception because growth after metamorphosis results in measurable size increase as discussed below. The histogram of the number of minute specimens in relation to shell length or shell width exceptionally shows a small shift with regard to the histogram of the adults (fig. 14).

Species without or with only an insignificant metamorphosis during shell growth, like those of the genera *Creseis*, *Styliola*, *Hyalocylis* and *Clio* (Van der Spoel, 1967, table XV), show a gradual decrease in shell growth with increasing age but the shell does not absolutely stop growing (Van der Spoel, 1969c) which makes the histograms less simple to explain.

Comparison of the populations of *Diacria trispinosa* in fig. 1 is possible since age does not influence size variation. The same comparison is made for size variation in *Clio pyramidata*. In this species age does influence size because it was not possible to discriminate age classes.

The diagram of *Diacria trispinosa* (fig. 1) proves that size differs at different latitudes; the diagrams for *Clio pyramidata* only show that specimens may reach different maximum length at different latitudes. The size differences found in the populations of different latitudes run parallel to the different formae described for *Clio pyramidata* (Van der Spoel, 1967) but they are not the characters on which the form can be discriminated. In relation to this it would be interesting to study populations of *Clio pyramidata* from the Mediterranean as specimens of this area differ in some characters from specimens found in the Atlantic Ocean at the same latitude. The few specimens at my disposal from the Straits of Messina have embryonic shells with a general shape like that of the forma *pyramidata* but with a sharp point such as known in the forma *lanceolata*; bending of the lateral sides starts more anteriorly, and is not as strong as in the latter form. Most specimens were too damaged to measure the shell, but from the soft parts it appears that they are larger than specimens from about 38°N in the Atlantic. Probably it is the salinity of the Mediterranean which influences size. Further studies are needed to discover the systematic position of Mediterranean specimens.

More or less isolated seas like the Mediterranean, Red Sea, China Sea, etc. very probably are inhabited by taxonomically or at least morphometrically distinct populations; we will try to prove this by more detailed studies in the future.

LARGER AND SMALLER FORMAE

The occurrence of larger and smaller forms may be the result of a general tendency of size increase or decrease in certain areas. *Cavolinia longirostris* forma *angulosa* is certainly a small form of *C. longirostris* but it occurs together with the larger forms in the same area. For some formae of *C. uncinata* (Rang, 1829) and *Diacria quadridentata* the same holds good. This shows that there are two types of larger and smaller forms, viz., those dependent on latitudinal (or otherwise) varying ecological factors and those preserved by genetical factors only. It is not altogether out of the question, of course, that genetical factors also influence the first type of variation (Van der Spoel, 1970b). The first type of large and small forms, varying parallel to ecological factors, changes gradually from one population into another and clinal variation does occur here. The second type of forms, dependent on genetical factors, may change into each other or may occur sympatrically without interbreeding. The first type consequently refers to a polytypic species (Van der Spoel, 1970b), the second type consists of a single taxon with a large amount of variation (a polytypic or a polymorphic species).

A third problem occurs, when variation in shell thickness is considered viz., that of the increase in thickness independent of

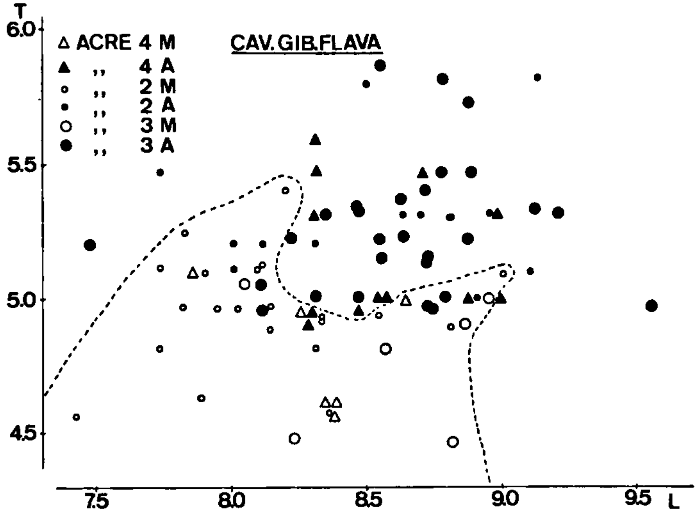


Fig. 10. Graph of shell length and thickness in *Cavolinia gibbosa* forma *flava* collected on the Ocean Acre cruises near Bermuda. The interrupted line indicates the upper limit of the minutes.

increase in length and width. In *Cavolinia tridentata* (forma *platea*), *C. gibbosa* (forma *flava*) and in *C. globulosa* typical, flat, specimens have been described. The shell thickness is determined partly by growth of the upper part of the ventral surface bending inwards. Final growth causes relatively less increase in thickness than in width and length.

Minute specimens of *C. gibbosa* (fig. 10) and *C. globulosa* are, however, usually flatter than adult specimens. Data concerning *C. tridentata* are not available. The growth of the ventral surface is thus at the end of the growth period (i.e., after metamorphosis) stronger than the growth of the dorsal surface. When the dorsal surface bends ventrad at the shell aperture, growth of the dorsal surface does not increase shell length at all (fig. 11). The dorsal surface bends ventrad in *C. gibbosa* and *C. globulosa*, which explains the small thickness of the minutes in relation to the no longer increasing shell length of the adults. Shell width is not compared with shell thickness as the width is not affected by the final growth in the present species. For *Cavolinia* it is generally found that the width is comparatively smaller in adults than in minutes, while shell thickness is relatively

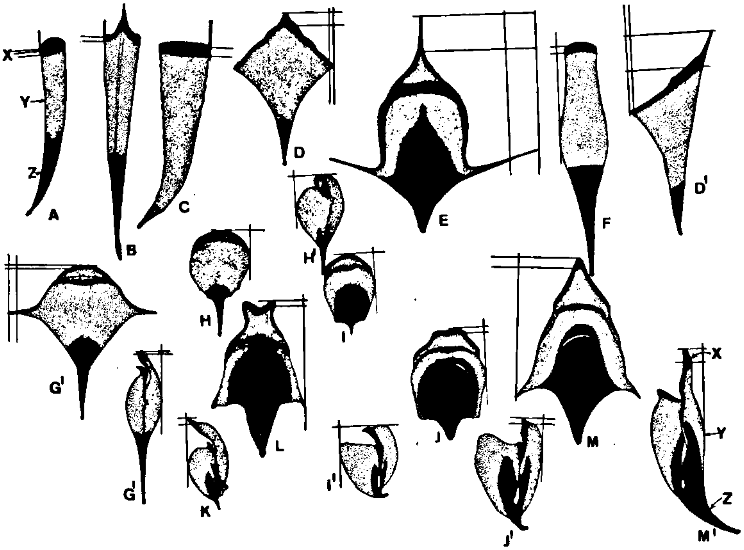


Fig. 11. Different types of growth in Cavoliniidae; X, part grown during the adult period, Y, part grown during the minute or skinny stage, Z, part grown during the juvenile stage; A, *Creseis virgula*; B, *Styliola subula*; C, *Hyalocylis striata*; D, *Clio pyramidata*; E, *C. cuspidata*; F, *Cuvierina columnella*; G, *Diacria trispinosa*; H, *D. quadridentata*; I, *Cavolinia gibbosa*; J, *C. globulosa*; K, *C. longirostris* forma *longirostris*; L, *C. longirostris* forma *angulosa*; M, *C. inflexa*.

larger in adults than in minutes, which means that growth in width is smaller than in length and that growth in length is smaller than in thickness. The flat formae mentioned above thus may be the result of variability in growth caused by genetical, but also by ecological, factors.

These differences in size increase are very small as the increase in size by final growth in the adult stage is small and masked by the shell shape, which does not allow final growth to change much in the outline of the shell in Cavoliniidae. In the other Cavoliniidae no masking of the final growth is effected, which once more illustrates the primitive characters of these genera (*Creseis, Clio, Styliola, Hyalocylis*). The floating capacity is partly determined by the shell shape and the better the species is adapted to floating, the quicker the final shape has to be realized. The floating capacity (F) as shown by Van der Spoel (1968b) can be expressed in the formula:

$$F = \frac{(D + 2S + B) . A . T}{L . M . P}$$

A = part of shell anterior to lateral spines
B = width of shell
D = length of dorsal shell lip
L = length of shell
M = distance between geometrical centre of shell and greatest thickness
S = length of lateral spines
T = thickness of shell

The different morphological shell-types are given in fig. 11, with the shell part grown in the juvenile stage (Z), the part grown in the minute, skinny or immature period (Y, dotted) and in the adult period (X). Growth is slow in the black, and very fast in the dotted area. In this period (dotted) the sizes S, M and A in the above formula become fixed; this also holds good for T and B in most species. Only in the best adapted species (fig. 11, H and I) all sizes become completely fixed in the minute stage.

TWO MORPHOMETRICALLY DETERMINED FORMAE

Cuvierina columnella

The size of specimens from different oceans can differ as described for *Cavolina uncinata* forma *uncinata* and forma *pulsata* (Van der Spoel, 1969a) (fig. 12). Comparison of twelve samples of *Cuvierina columnella* showed that what formerly was considered to be the forma *columnella* is to be divided into a small Indo-Pacific and a larger Atlantic form. The relation of these two forms is problematic: are they geographically separated or not? A geographical barrier between Indo-Pacific and Atlantic populations is unknown at present. Distribution of the two forms south of Africa seems to be continuous from the Indian into the Atlantic coast. It seems, therefore, best to consider these forms as formae of one species. *Cuvierina columnella* was described originally by Rang (1827) from the Indian Ocean. The name *columnella* is thus given to the forma of the Indo-Pacific area and the Atlantic populations now constitute the forma *atlantica* new to science. Consequently the genus *Cuvierina* may be subdivided as follows:

1. *C. columnella* (Rang, 1827) forma *columnella* (Rang, 1827) (fig. 13C-E).

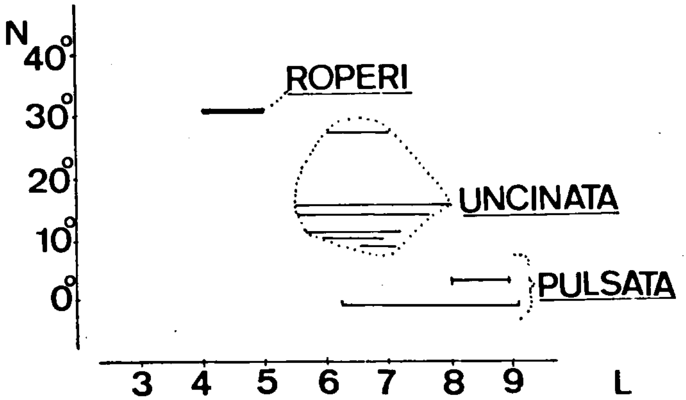


Fig. 12. Diagram of variation in shell length in populations of *Cavolinia uncinata* forma *uncinata*, forma *pulsata*, and forma *roperi*.

2. *C. columnella* (Rang, 1827) forma *atlantica* nov. forma (fig. 13A-B).
3. *C. columnella* (Rang, 1827) forma *urceolaris* (Mörch, 1850) (fig. 13F-G).

There is a possibility that *columnella* s.s. has been regarded as identical with the forma *urceolaris* as the characters of the latter were often incompletely described.

The presence of the three different types is proved by Boas (1886). In his fig. 95a-c the forma *urceolaris* is shown, d-g depicts the forma *columnella* (smaller than 7 mm), and under k, h, m, o, and p the forma *atlantica* (larger than 7 mm) is shown. Only the specimen figured in fig. 95n is problematic, but the absence of an exact locality precludes a discussion.

Boas (1886 : 215) writes: "Var.*typica*" (= forma *columnella* + forma *atlantica*)": coquille en général plus grande, septum grand; la coquille n'est pas très bombée, la partie antérieure en est allongée et le col sensiblement plus étroit que l'ouverture." He continues: "Var. *urceolaris*" (= forma *urceolaris*)": coquille plus petite, septum petit; la coquille est fortement bombée, sa partie antérieure courte, et le col à peine plus étroit que l'ouverture."

Tesch (1948 : 12) has stated: "It is well known that this species presents two subspecies. One is the proportionately longer form, typical in the Atlantic, but in the Indo-Pacific another, shorter and broader, is found, the variety *urceolaris* Mörch . . ."

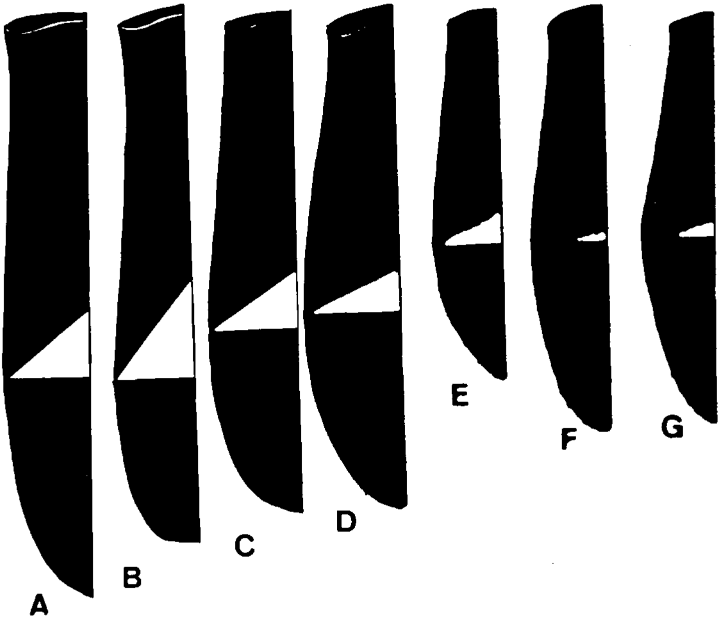


Fig. 13. *Cuvierina columnella*; A, B: forma *atlantica* from 41°55′N 32°22′W and 37°05′N 54°34′W respectively; C, D. E: forma *columnella* from 25°10′N 127°45′E, 32°13′N 167°25′W and 4°31′S 99°24′E respectively; F, G: forma *urceolaris* both from 3°40.5′N 137°53′E. Left halves of the shells are enlarged to the same degree, the white triangle gives the distance between the thickest part of the shell and the middle of the shell.

The discrimination between the formae *columnella* and *urceolaris* is thus usually based on size differences, while more attention should have been given to the shell shape and structure. The specimens identified by Boas seem to have been selected by him especially with regard to their shell shape.

Mörch (1850 : 32) has stated concerning *urceolaris*: "T. hyalina, ventricosa fusiformi, externitate postica convexa, antica ab uno latere applanata, oblique truncata; apertura reniformi. Long. 6½; lat. 2½; apertura 2 mm lata, 1 mm alta." The figure (Mörch, 1850, fig. 8) clearly shows the high position of the point at which the greatest shell diameter is found.

In general one may consider the larger forma *atlantica* to be restricted to the Atlantic Ocean and the smaller forma *columnella*,

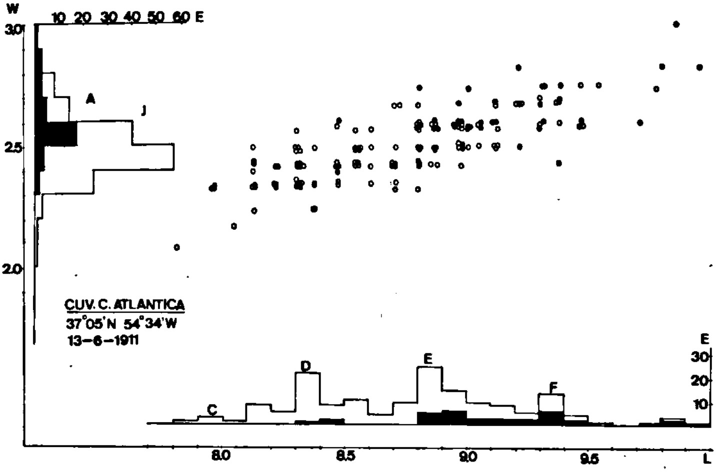


Fig. 14. Graph of shell length and width in *Cuvierina columnella* forma *atlantica* (Dana Sta. 299), with tops in frequency (C-F).

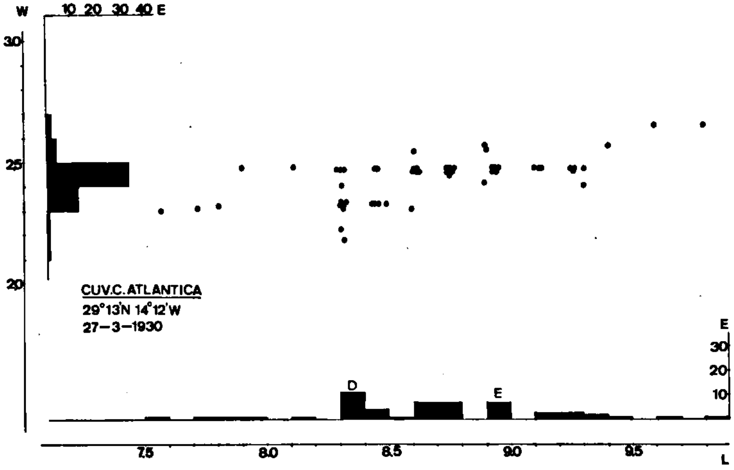


Fig. 15. Graph of shell length and width in *Cuvierina columnella* forma *atlantica* (Dana Sta. 4017), with tops in frequency (D-E).

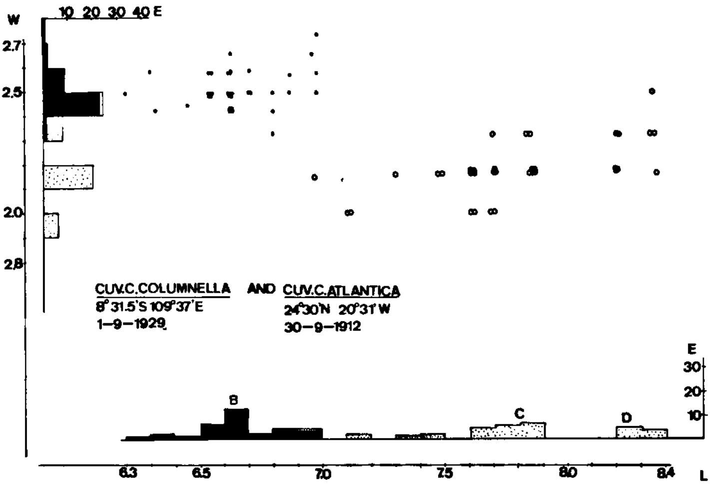


Fig. 16. Graph of shell length and width in *Cuvierina columnella* forma *columnella* (black) and forma *atlantica* (dotted, and open circles) (Dana Sta. 3805b and 662) to show differences; with tops in frequency (B-D).

like the forma *urceolaris*, to be restricted to the Indo-Pacific area.

The specimens figured by Boas (1886, fig. 95n) and Van der Spoel (1967, figs. 74, 75, 282) show that larger specimens of the forma *atlantica* type may be found in the Indo-Pacific area.

The frequency distribution of size in the populations of the three formae (figs. 14-17) demonstrates the typical degree of variability of the forms. In the *C. columnella* forma *atlantica* population of 37°05'N 54°34'W shell width varies between 2.0 and 3.0 mm with the modial value of 2.5 mm which is normal for almost all populations of the species. Shell length, in this population, varies between 7.8 and 10.0 mm with tops in frequency near 8.0, 8.4, 8.9, 9.4 and 9.9 mm (indicated in fig. 14 with C, D, E, and F respectively). In fig. 15 the tops D and E and in fig. 16 the tops C and D are also found in *atlantica* populations. In the populations of *urceolaris* from 3°40.5'N 137°35'E tops are found near 6.0 and 6.7 mm, indicated with A and B. Top A is most characteristic for the forma *urceolaris* (see also fig. 18), while top B represents the specimens more typical of the forma *columnella*. The phenomenon of these tops will be discussed later (see p. 140).

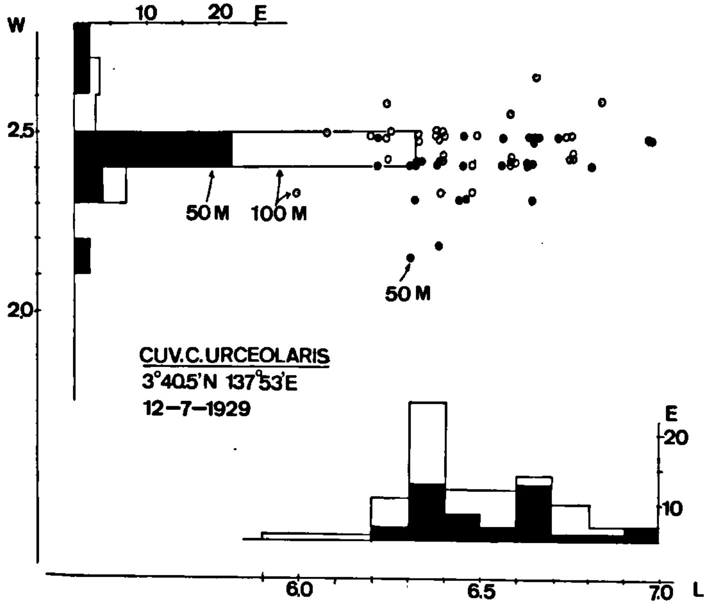


Fig. 17. Graph of shell length and width in *Cuvierina columnella* forma *urceolaris* (Dana Sta. 3751).

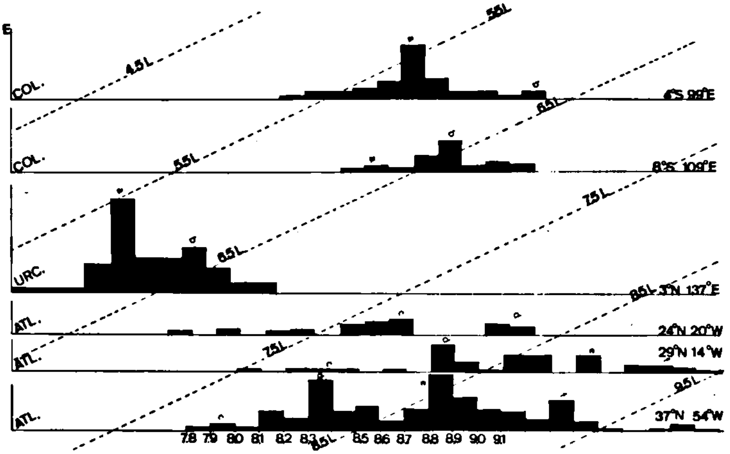


Fig. 18. Graph of shell length and number of specimens in *Cuvierina columnella* forma *columnella*, forma *urceolaris*, and forma *atlantica* from different areas to show the different tops (a-f) occurring in different populations. The oblique broken lines connect points of the same length on the horizontal

Cuvierina columnella (Rang, 1827)
forma *columnella* (Rang, 1827)
fig. 19

Shell bottle-shaped, greatest diameter distinctly below the middle of the shell, a small constriction below the reniform aperture, caudal septum convex. Shell not or only slightly hyaline, surface smooth. Shell length varies between 4.0 and 8.0 mm. Though found in a larger area this forma can be considered to be most typical for the East Pacific.

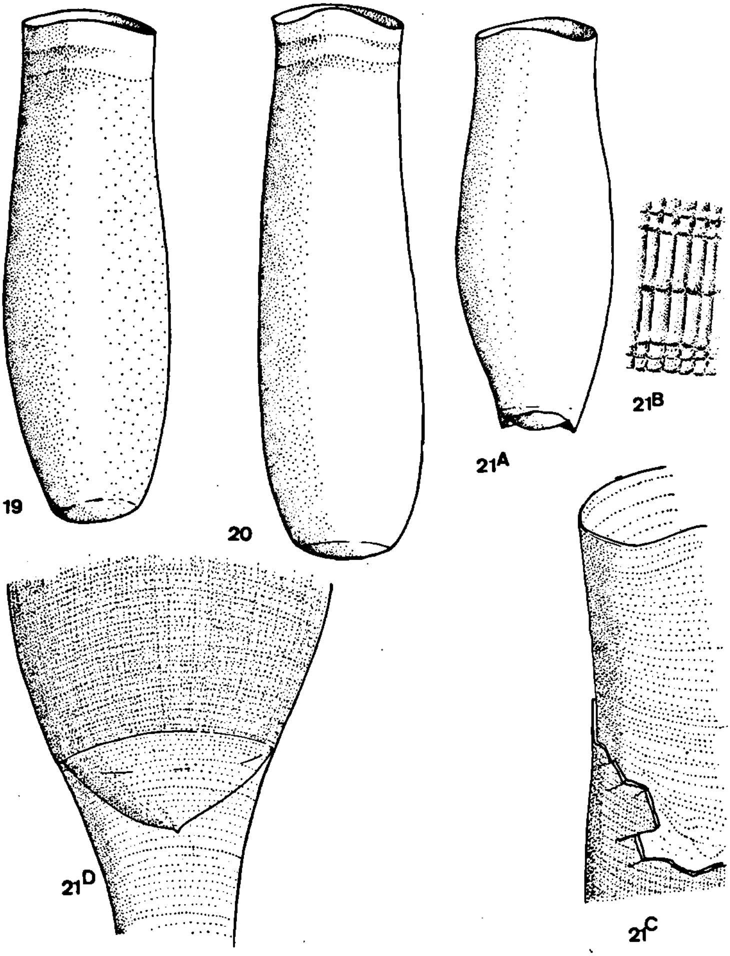
Cuvierina columnella (Rang, 1827)
forma *atlantica* nov. forma
fig. 20

Type locality: Dana Expedition Sta. 299, 37°05′N 54°34′W (Atlantic Ocean). 13-6-1911 $09^{\circ\circ}$ hs 34 m wire, ringtrawl S 200. Holotype in the Universitetets Zoologiske Museum, Copenhagen.

Shell bottle-shaped, greatest diameter close to caudal shell end, a clear constriction below the reniform aperture, caudal septum convex. Shell not hyaline, surface smooth. Contrary to the above forma the increased shell diameter at the caudal end does not show a distinct swelling. Shell length varies between 7.0 and 10.0 mm. This forma is most typical for the Atlantic Ocean.

Cuvierina columnella (Rang, 1827)
forma *urceolaris* (Mörch, 1850)
fig. 21A

Shell hyaline, bottle-shaped, greatest shell diameter close to the middle of the shell, no or only a small constriction below the reniform aperture, caudal septum convex. The shell shows a clear pattern of longitudinal and transversal striae. The longitudinal striae are not found in the juvenile shell which is similar to that of the two other formae except for its striation (fig. 21B). When the shell is repaired after damage the longitudinal striation disappears (fig. 21D). This forma is found in the Indo-Pacific Ocean. The length of the shell of this forma is not diagnostic.



Figs. 19-21. *Cuvierina columnella*. 19. forma *columnella*, ventral view (Dana Sta. 4778, 32°13'N 167°25'E). 20. forma *atlantica*, ventral view, holotype (Dana Sta. 229, 37°05'N 59°34'W). 21. forma *urceolaris* (Dana Sta. 3751, 03°40.5'N 137°53'W): A, complete specimen, ventral view; B, shell sculpture, highly enlarged; C, area near closing membrane to show absence of longitudinal striae in this section; D, repaired shell area to show absence of longitudinal striae here. Figs. 19, 20 and 21A x 8.5 approximately.

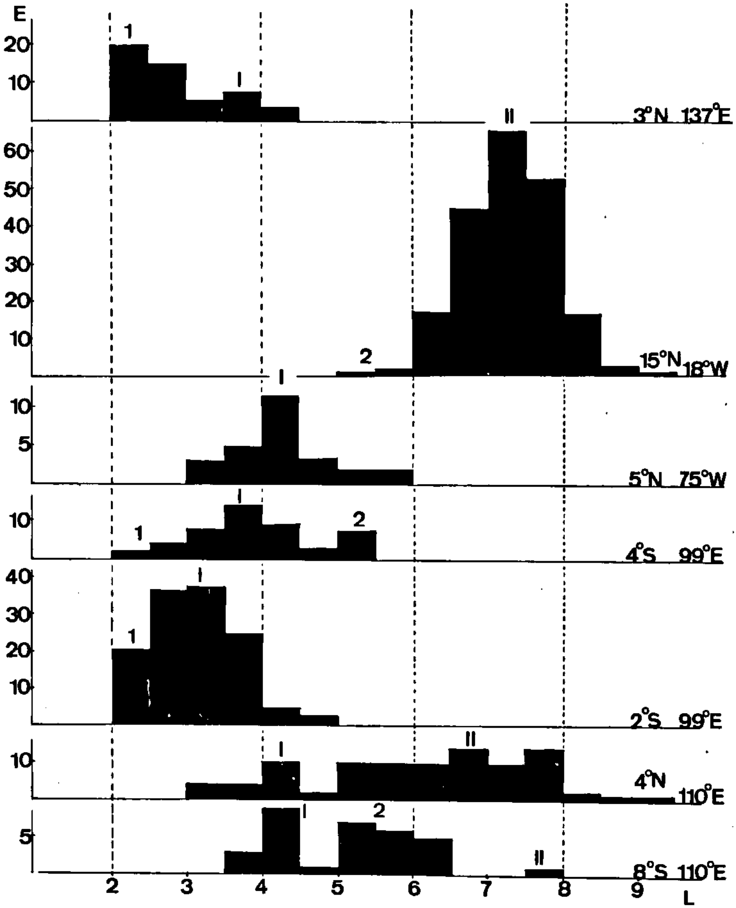


Fig. 22. Graph of shell length of *Cavolinia longirostris* to show length variation in different populations; top 1 represents juvenile, top I adult specimens of the forma *longirostris*, while top 2 represents juvenile and top II adult specimens of the forma *limbata*.

Cavolinia longirostris

Variation and frequency distribution of the length of the shell in different populations of *Cavolinia longirostris* forma *longirostris* is given in fig. 22. It is evident that both a large and a small type are

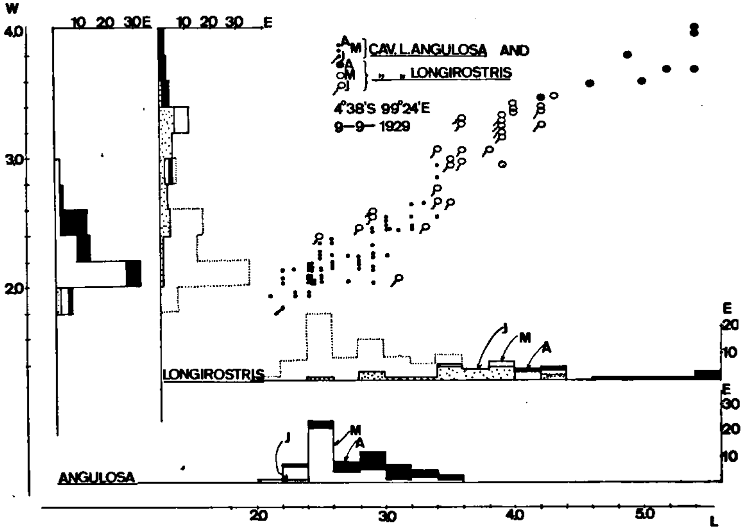


Fig. 23. Graph of shell length and width in *Cavolinia longirostris* forma *longirostris* and forma *angulosa* (Dana Sta. 3784. IV). The dotted line represents the sum of the histograms of the two formae.

present in these populations. Tesch (1913, 1946, 1948, 1950) and Dall (1908) have already mentioned the occurrence of a large and small form. Tesch (1946) is of the opinion that these size differences are not due to age differences in which I completely agree. Frontier (in litt.) is of the opinion that, at least in some populations, these size differences are the result of age differences. Most authors did not attach taxonomic value to these two types and the present author (Van der Spoel, 1967) has considered them synonymous. Studies on size variation and re-examination of the literature prove that d'Orbigny (1836) correctly described the larger form as *"Hyalaea limbata"*. For the smaller form he used the name *"Hyalaea longirostra"*.

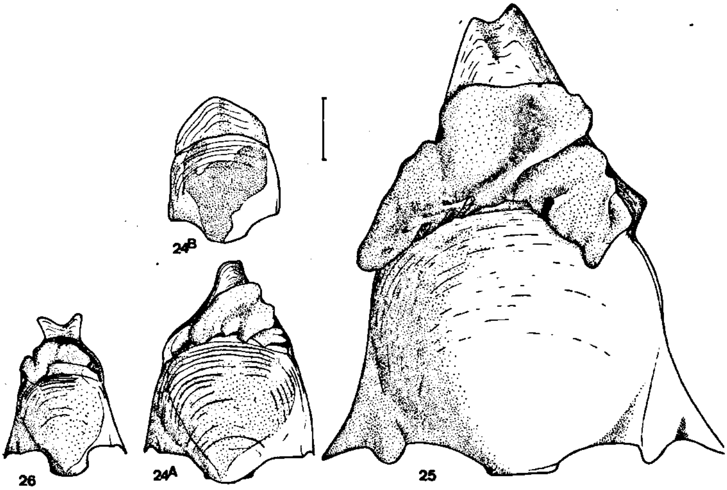
In fig. 22 four tops, regularly occurring in different populations are found, viz., the tops 1, I, 2, and II. The tops 1 and 2 represent juvenile specimens, the tops I and II adults. The tops 1 and I belong to the smaller, the tops 2 and II to the larger form. In fig. 23 the size frequency distribution is given in a population from 4°38'S 99°24'E containing all three developmental stages of the forma *longirostris* (smaller type) and of the forma *angulosa*. The juveniles of the smaller type of the forma *longirostris* measure from 2.4 to 4.4 mm, the minutes, or skinnies, from 3.4 to 4.4 mm, and the adults from 4.0 to 5.3 mm. The stage of maturity has been checked in some specimens by means of histological techniques. In fig. 22 top I is also found between 4.0 and 5.5 mm for populations from 5°N 75°W, 4°N 110°E, and 8°S 110°E. A population at 2°S 99°E and one at 3°N 137°E shows top I shifted to the left (lower size values) which is explained by the fact that in these typically equatorial areas shells usually grow not as large as at somewhat higher latitudes.

The II tops are found in populations at 15°N 18°W and 4°N 110°E, which proves that specimens of the larger type responsible for the occurrence of these II tops are not comparable with e.g., the larger specimens of *Diacria trispinosa* forma *trispinosa* found at higher latitudes. The II tops show that the large form is a separate forma occurring separately or together with the small forma. In those samples where the small and large forms are mixed, the formae *lanceolata* and *convexa* of *Clio pyramidata* are also often found mixed. Moreover, the forma *angulosa* is found frequently mixed with these two formae so that the homogeneity of the samples is subject to doubt.

Cavolinia longirostris (Blainville, 1821)
forma *longirostris* (Blainville, 1821)
fig. 24

The smaller form was originally described by Blainville (1821 : 81) from the Atlantic Ocean at "22°9' latitude", so that it is considered the forma typica of the species.

Shell hyaline, ventral surface rounded, with strong transversal ribs especially near shell aperture, growth lines on ventral and dorsal surface, dorsal surface with five longitudinal ribs, upper lip regularly bent ventrad, lateral spines usually projecting more or less caudad. The line connecting the lateral spine points runs anterior to the most caudal point of the shell. The dorsal lip of the shell is provided with a gutter-shaped rib which ends in a rounded top. The greatest shell width is found between the lateral spines. Shell width varies from 1.5 to 4.0 mm and shell length from 2.0 to 6.0 mm. Variation in one population of this forma is higher than in the other formae, the variation coefficient is usually about 20; in the population given in fig. 37 it is 19.31%.



Figs. 24-26. *Cavolinia longirostris*. 24. forma *longirostris*, adult stage (A) and juvenile stage (B) (Dana Sta. 3751. IV, 3°40.5'N 137°53'E). 25. forma *limbata*, adult stage (Dana Sta. 4006. IV, 15°31'N 18°05'W). 26. forma *angulosa*, adult stage (Dana Sta. 3751. IV, 3°40.5'N 137°53'E). All in ventral view, scale 1 mm.

Cavolinia longirostris (Blainville, 1821)
forma *limbata* (D'Orbigny, 1836)

fig. 25

Synonymy: *Hyalaea limbata* d'Orbigny, 1836: 101 (atlas, 1846) Pl. VI figs. 11-15. ? *Cavolinia couthouryi* Dall, 1908: 501.

Shell not hyaline, ventral surface rounded, with fine transversal ribs especially near the aperture, growth lines on ventral and dorsal surfaces not as clear as in the preceding forma, dorsal side with five longitudinal ribs, upper lip regularly bent ventrad, lateral spines projecting laterally and usually not bent caudad as in the preceding forma.. The line connecting the lateral spines also runs through the most caudal point of the shell. The dorsal shell lip is provided with a gutter-shaped rib which ends in an incision like a swallow's tail. The greatest shell width is found between the lateral spines. Shell width varies from 3.0 to 8.0 mm and shell length from 5.0 to 10.0 mm. The variation in one population is usually small, with a variation coefficient of about 5; in the population of fig. 36 it is 4.56%.

Cavolinia longirostris (Blainville, 1821)
forma *angulosa* (Gray, 1850)

fig. 26

Upper lip separated from the rest of the dorsal surface by a deep transversal groove. The shell is glassy, a little more brown than in the other two formae. The dorsal lip is more clearly bifid than in the other formae, and the lateral spines are more pointed. The most posterior shell part, with the caudal spine mark, is projecting more caudad so that the line connecting the lateral spine points extends far anterior to the caudal shell point. Shell width varies from 1.9 to 3.1 mm, and the shell length from 2.0 to 4.0 mm.

Cavolinia longirostris (Blainville, 1821)
forma *strangulata* (Deshayes, 1823)

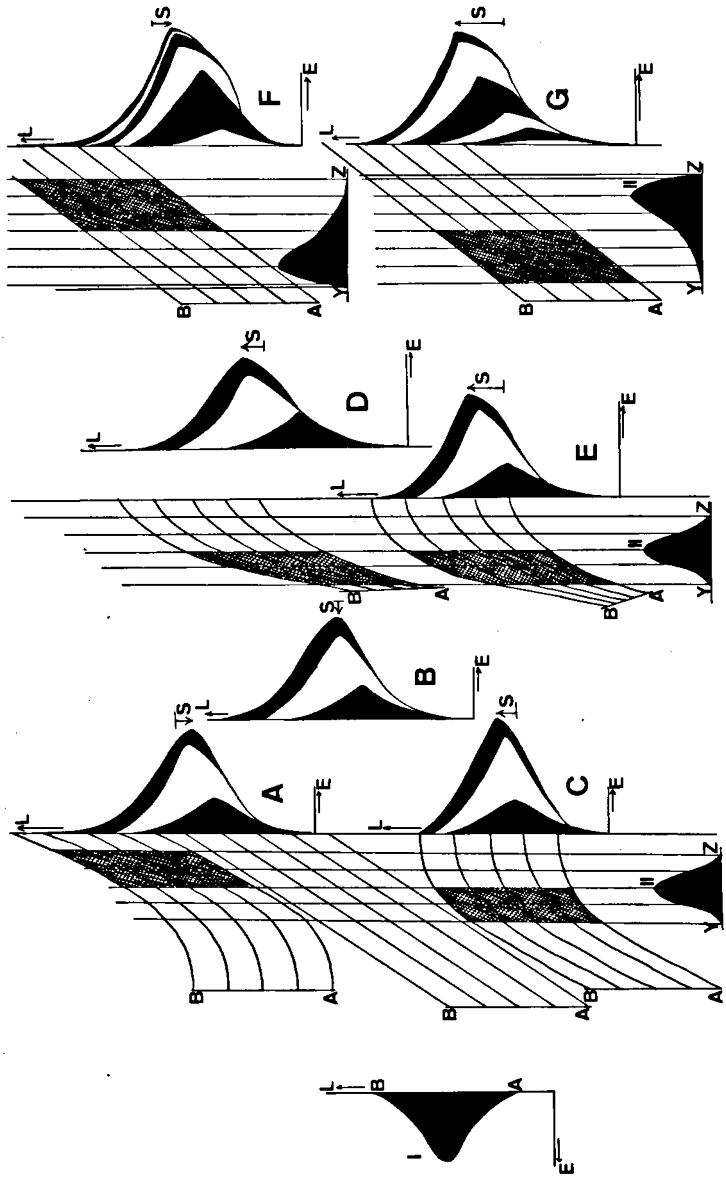
Shell characterized by an abrupt lateral constriction in the rostrum which gives rise to a tubercle distally, separated completely from the dorsal surface. The lateral spines of the shell are less developed than in the forma *longirostris*. The shell has nearly the same dimensions as that of *longirostris* s.s.; in structure the formae *longirostris* and *strangulata* are very much alike.

SIZE FREQUENCY DISTRIBUTION WITHIN POPULATIONS

When specimens of a population show normal and regular growth nothing will disturb regular frequency distribution of size in the population and a curve of the number of specimens in relation to the shell length (or width) will be bell-shaped. A population is considered here a group of specimens forming a swarm or "local population" (Mayr, 1963) originating from one or more broods from comparable age in which predation and mortality are non-selective on size distribution. The natural situation includes such predation and mortality.

When at a certain moment growth comes to an end, variation may neither show any irregularity. When, however, growth stops during a certain period of life not all specimens will stop growing at the same

Fig. 27. Diagram to demonstrate possible changes in size frequency distribution during growth in a population. Curve I: size distribution after hatching, curve II: frequency distribution (fd) for the occurrence of shell metamorphosis and growth stop; curve A: fd after growth stop during period of increasing growth rate, curve C: fd after growth stop during a period of decreasing growth rate, curves D and E: like C but indicating faster growth, curves F and G: fd after a growth stop during a period of regular growth, influenced by a skewed fd for growth stop; curve B: fd after a period of normal and regular growth. The arrow S indicates the distance between mean and modial value (for further explanation see p. 128).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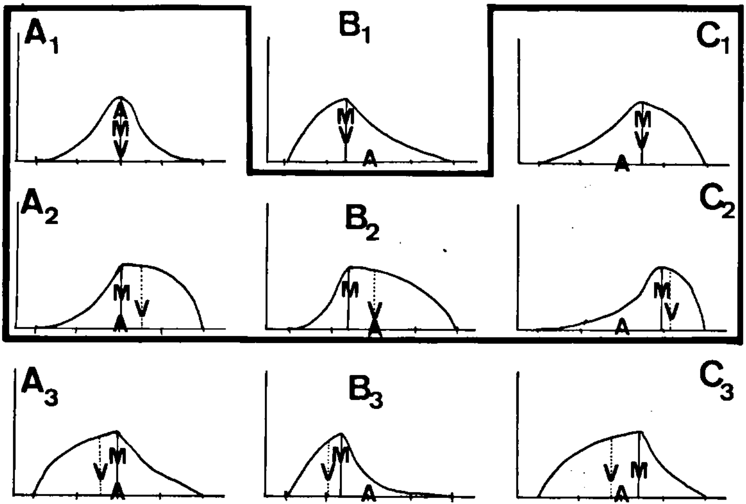


Fig. 28. Possible size frequency distributions in a hypothetical population as explained on p. 129.

moment or at the same time after hatching, which may influence the type of size distribution in populations.

When for example, growth proceeds first quickly and later on slower, size increase will proceed according to a logarithmical curve (fig. 27C-E). The normal bell-shaped graph of frequency distribution of shell size, as found, for example after hatching of the specimens (fig. 27, curve I), may be altered when over a restricted period (fig. 27, period Y-Z) growth stops. When the period Y-Z shows an optimal moment for growth stop and less optimal moments as expressed in the curve (fig. 27, curve II), it is clear that the number of specimens which stop growing is smaller in the first half of the period Y-Z (hatched in the growth curves). When growth is normal and regular, resulting in a constant increase of size, the influence of the growth stop does not change the symmetrical curve of size variations (fig. 27B). When growth is slow at first and faster later on, the growth stop will influence the frequency distribution in a reverse manner: a larger number of small specimens will stop growing in the first half of period Y-Z and only a small number of larger ones remains (fig. 27A). Growth speed influences the degree of changes, but not the character of the change in variation (fig. 27D-E).

The optimum moment for growth stop in the period Y-Z may not coincide with the average of extreme values of the period Y-Z, which will influence final size frequency distribution in populations: the modial value shifts with regard to the average of extreme values and the mean value shifts with regard to the modial value (fig. 27F-G).

Curves of size variation in populations of Cavoliniidae usually do not show identical values for the mean, modial and average of extreme values. The different types of curves which may be found are given in fig. 28.

Curve A1 (fig. 28) may occur as explained above and in fig. 27B, curve B2 as explained in fig. 27A, curve B3 as explained in fig. 27F, curve C3 as explained in figs. 27C, G, and curve C2 as explained in figs. 27D, E. The types A1, B2, B3, C2, and C3 are the most important for analysis of the frequency distribution in populations.

Changes as mentioned (fig. 27) can be superimposed on "abnormal" size variation of the juveniles if juveniles show size variation aberrant from the normal bell-shaped curve. The curves B2 and C3 may also have another origin than mentioned above. When growth does not stop and the original variation is of a bell-shaped type, a B2 curve may occur when the smaller specimens grow slower than the larger ones and a C3 curve may arise when smaller specimens grow faster than larger ones.

Variation in *Cavolinia globulosa* is already mentioned above. The size distribution of the juveniles (fig. 7) shows a curve of the B2 type for shell length as well as for shell width variation. This means that small specimens grow slower than larger ones. Size distribution in fig. 6 shows for the minutes and adults also a curve of the B2 type, which proves that the variation of the juveniles is somehow continued in the same way by the adults, probably without superposition of other influences. From this one may conclude that a growth stop, the metamorphosis, occurs abruptly or that shell growth gradually proceeds along a straight line and not along a logarithmical curve.

In the population represented in figs. 6 and 7 specimens of between 4.0 to 4.5 mm in length are absent. This shows that either the juveniles belong to another, much younger, brood than the minutes and adults, or that the growth from 4.0 to 4.5 mm in length proceeds very quickly, i.e., faster than in the other periods of life. It should be mentioned that in this species no important shell part is thrown off like in *Diacria* and *Cuvierina* (Van der Spoel, 1967, 1968a). When absence of animals between 4.0 and 4.5 mm in length

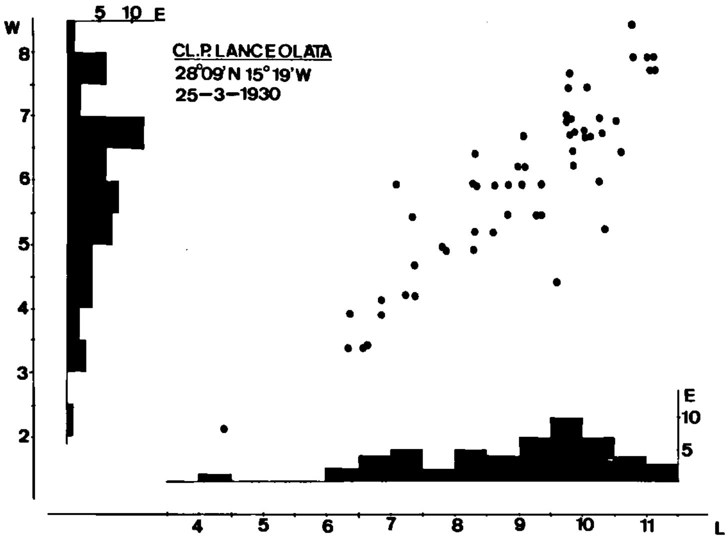


Fig. 29. Graph of shell length and width in *Clio pyramidata* forma *lanceolata* (Dana Sta. 4014).

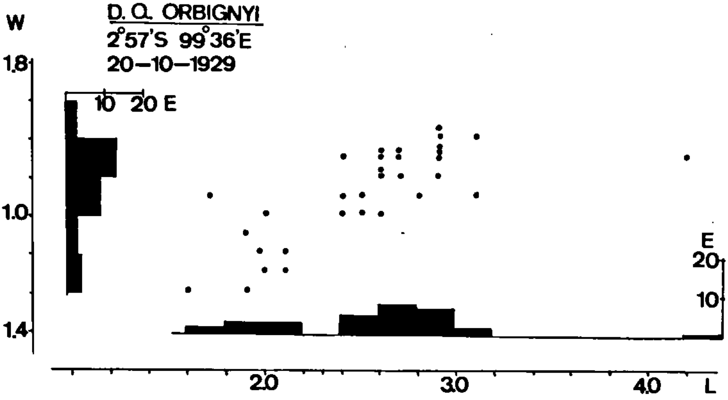


Fig. 30. Graph of shell length and width in juvenile specimens of *Diacria quadridentata* forma *orbignyi* (Dana Sta. 3860).

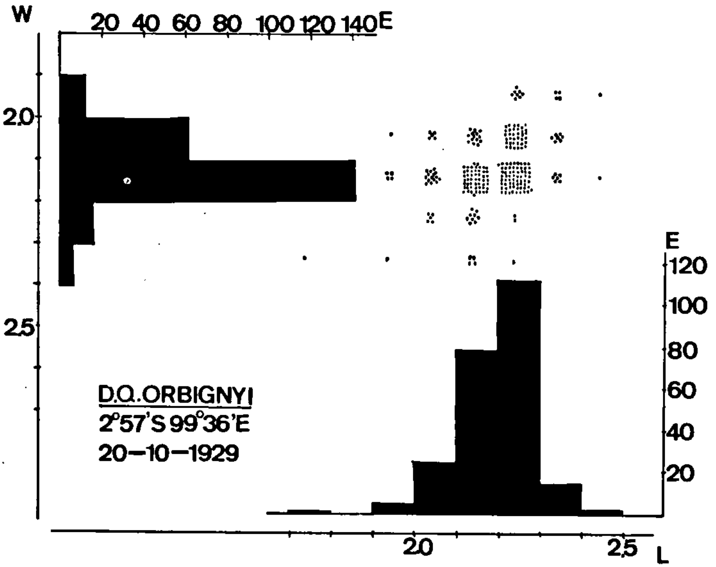
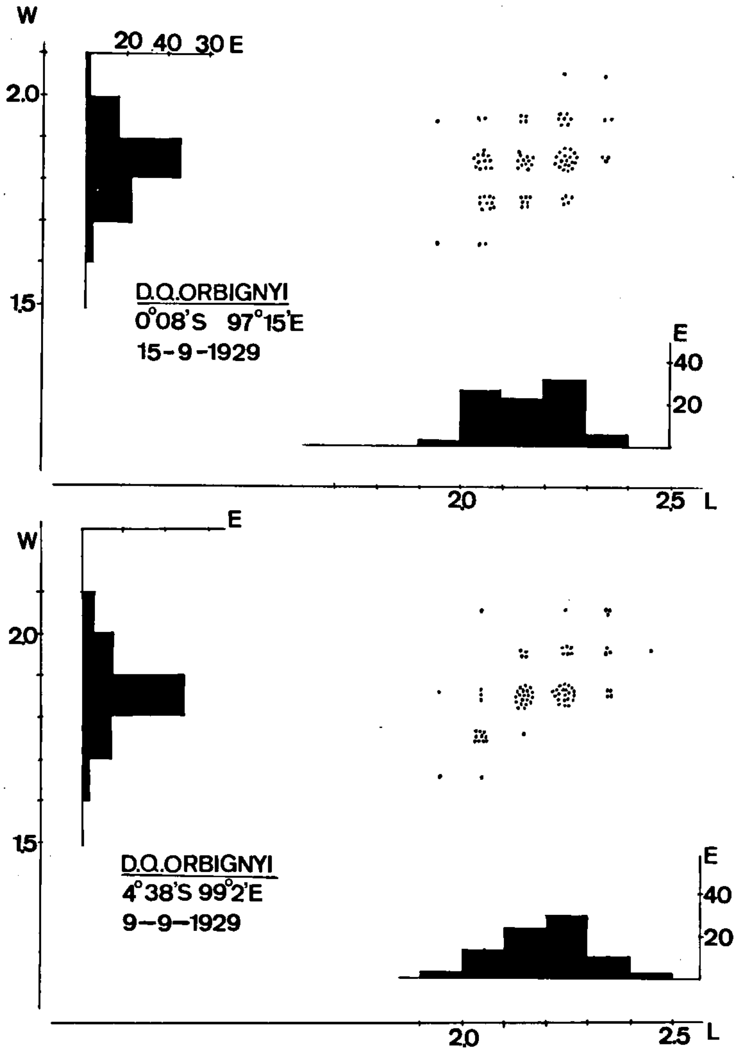


Fig. 31. Graph of shell length and width in adult specimens of *Diacria quadridentata* forma *orbignyi* (Dana Sta. 3860).

is due to higher speed of growth in this period, the possibility that growth proceeds regularly along a straight line is excluded and only an abrupt shell-growth stop can explain the reproduction of size variation of juveniles in the adults. The B2 curve of the juveniles, moreover, proves that the larger the juveniles, the quicker they grow, so that the only conclusion has to be that growth stops abruptly resulting in a random change-over of juveniles of different sizes into minutes. The presence of juveniles together with minutes and adults proves that not all juveniles change over at the same time though growth has stopped in all minutes and adults, which would result in the same size distribution among adults.

The phenomenon that larger specimens grow slower than smaller ones is found in *Clio pyramidata* (cf. Van der Spoel, 1969c) and the frequency distribution consequently shows a curve of the C3 type. In fig. 29 a population of the forma *lanceolata* (Lesueur, 1813) is represented and the C3 type of curve is clearly recognized.

In *Diacria quadridentata* forma *orbignyi* (figs. 30-31) the variation shows a curve skewed to the left. This is just the reverse aberration



Figs. 32-33. Graph of shell length and width in adult specimens of *Diacria quadridentata* forma *orbignyi*. 32 (top). Dana Sta. 3824. 33 (bottom). Dana Sta. 3841.

of the normal bell-shaped curve when compared with the curves of *Cavolinia globulosa* skewed to the right. Curves for shell length and shell width variation show the C3 type in the juveniles, the C3 type for shell length in the adults, and the A2 type for shell width. The same is shown for this species in figs. 32, 33, and 35. For the juveniles of *Diacria quadridentata* forma *orbignyi* one has to assume that growth of large specimens is slower than that of smaller ones, as the curve shows the C3 type. That the adults do copy, without superposition of other phenomena, the type of variation of the juveniles is not as easily acceptable because metamorphosis is so very important here (Van der Spoel, 1968a). But still the only possibility is that the same conclusions have to be drawn from these figures as have been drawn from figures for *Cavolinia globulosa*.

More accurate examination of the curves shows that in both species variation in the adults is smaller (standard deviation S=0.137, variation coefficient C.V.=2.835%) than in the juveniles (S=0.434, C.V.=19.806%) and the asymmetry in the size distribution of the adults is more pronounced than that of the juveniles which means that superpostion of a phenomenon as shown in fig. 27 may exist. From fig. 31 it is evident that during the metamorphosis between juvenile and adult stages a process as shown in fig. 27C or 27G has altered the variation in the adult *Diacria quadridentata* forma *orbignyi*. For the adults of *Cavolinia globulosa* (fig. 7) it seems that a process as shown in the figs. 27A or 27F has altered variation in adults. This agrees with the above conclusion, because juveniles in *D. quadridentata* grow slower when larger and in *Cavolinia globulosa* they grow slower when smaller. There is no indication that the situation shown in figs. 27F and G does occur in these two species.

Summarizing one may conclude that in *Cavolinia globulosa* growth of the juveniles is slower in small specimens and quicker in larger ones. The metamorphosis is a rather quick process, but it somewhat influences size variation since the tendency to produce B2 curves is stronger in adults than in juveniles. In *Diacria quadridentata* forma *orbignyi* the juveniles grow quicker when small and the metamorphosis also influences the variation resulting in a C3 type in the variation curve.

The size distribution of *Cavolinia globulosa* (figs. 6-7) is also found in *C. longirostris* forma *limbata* (fig. 36), forma *longirostris* (fig. 37), forma *angulosa* (figs. 38-39), *C. uncinata* forma *uncinata* (fig. 40), and forma *pulsata* (fig. 41). It is not surprising that the

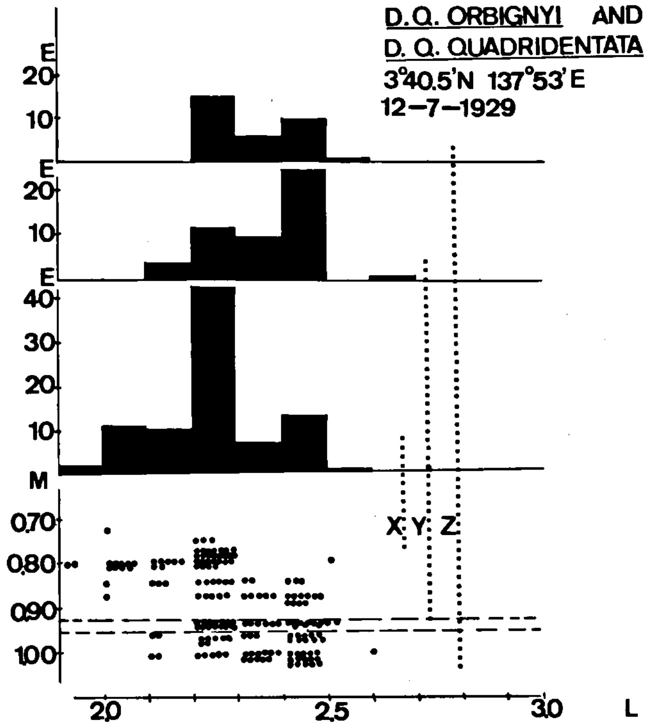


Fig. 34. Graph of shell length and diameter of caudal spine mark (M axis) in *Diacria quadridentata* (Dana Sta. 3751). The dotted line X connects the histogram of the specimens of the forma *orbignyi* with the plots in the lower graph, the line Y the histogram of the intermediates and line Z the histogram of the specimens of the forma *quadridentata* (for correlation see fig. 35 and for further explanation p. 142).

developmental biology in these taxa is almost similar (Van der Spoel, 1967). The size distribution of *Diacria quadridentata* forma *orbignyi* (fig. 31) is also found in the forma *quadridentata* (fig. 35, for juveniles see fig. 42), *D. trispinosa* forma *trispinosa* (fig. 44), forma *major* (fig. 43), and *C. tridentata* forma *tridentata* (fig. 45). All species of *Diacria* with comparable developmental biology show identical types of size distribution in the populations; this seems logical, but the similarity to *C. tridentata* forma *tridentata* is indeed remarkable.

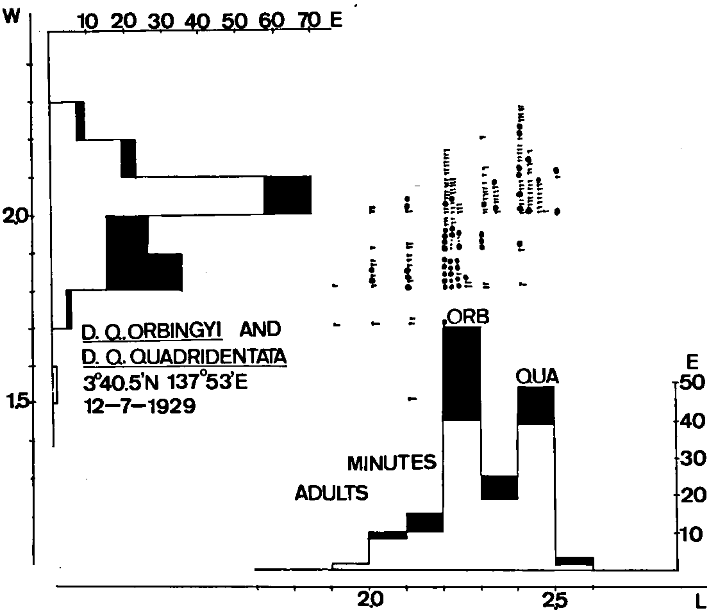


Fig. 35. Graph of shell length and width in *Diacria quadridentata* forma *quadridentata* and forma *orbignyi* (Dana Sta. 3751).

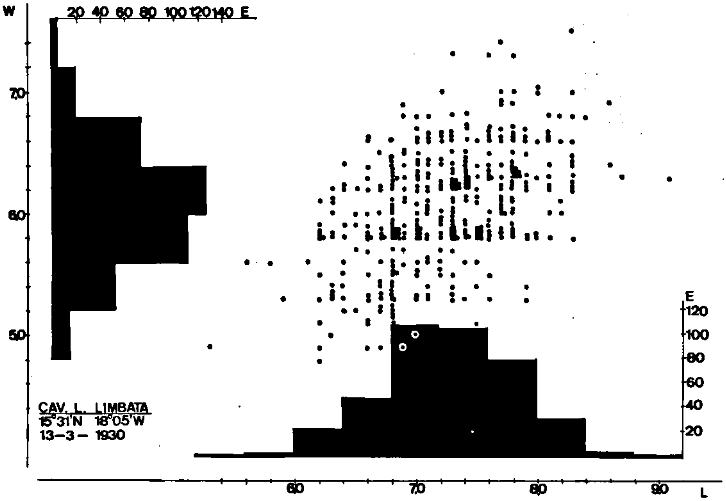


Fig. 36. Graph of shell length and width in *Cavolinia longirostris* forma *limbata* (Dana Sta. 4006).

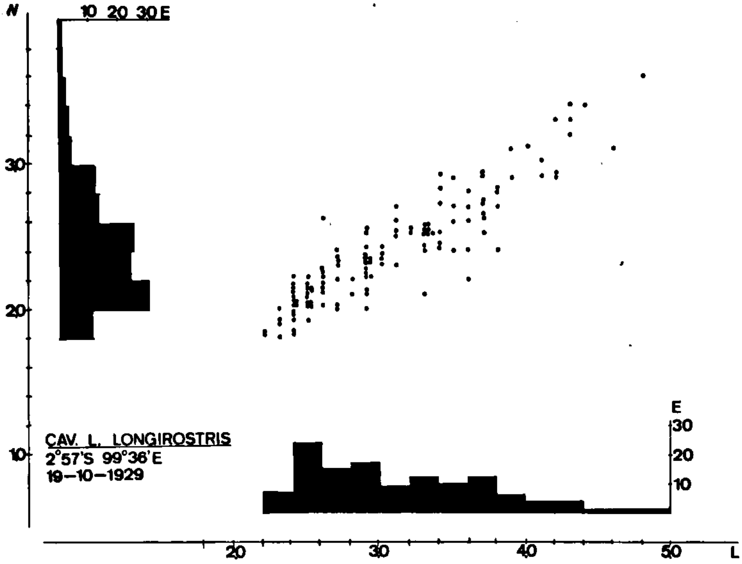


Fig. 37. Graph of shell length and width in *Cavolinia longirostris* forma *longirostris* (Dana Sta. 3860).

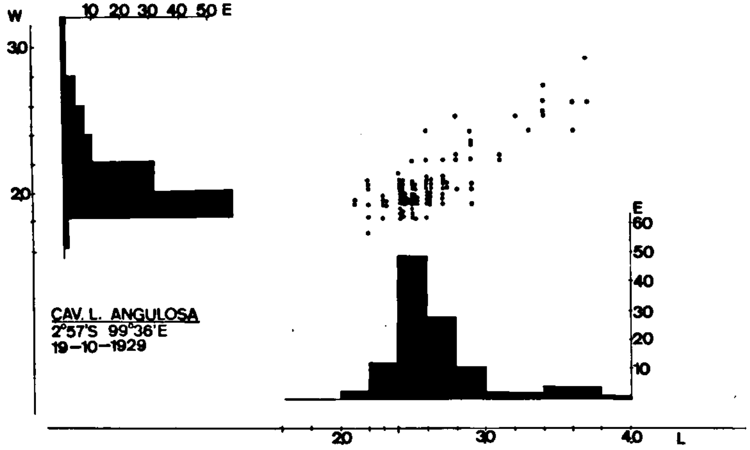


Fig. 38. Graph of shell length and width in *Cavolinia longirostris* forma *angulosa* (Dana Sta. 3860. VI).

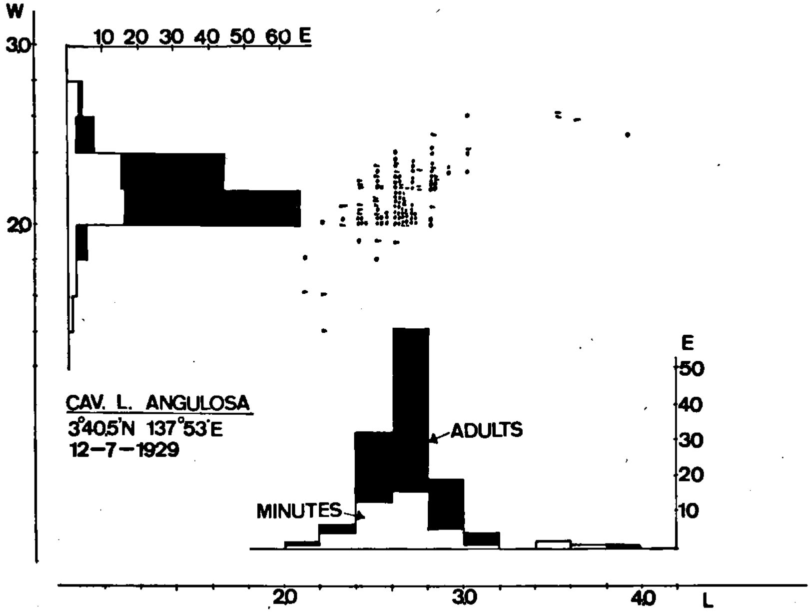


Fig. 39. Graph of shell length and width in *Cavolinia longirostris* forma *angulosa* (Dana Sta. 3751. V).

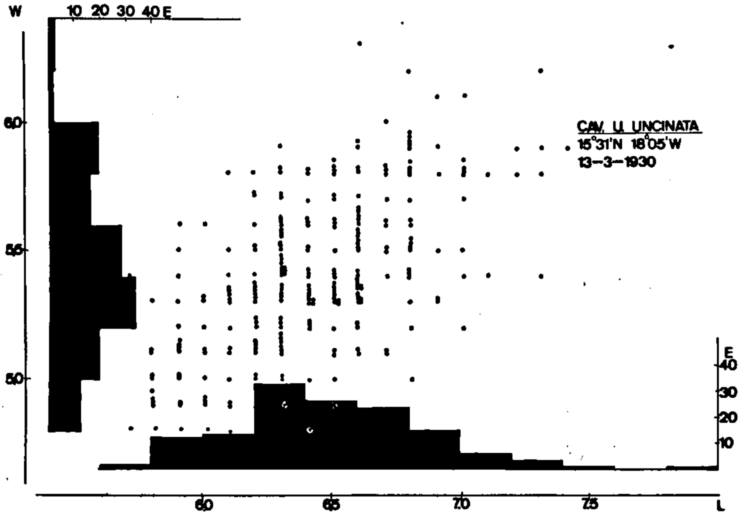


Fig. 40. Graph of shell length and width in *Cavolinia uncinata* forma *uncinata* (Dana Sta. 4006. IV).

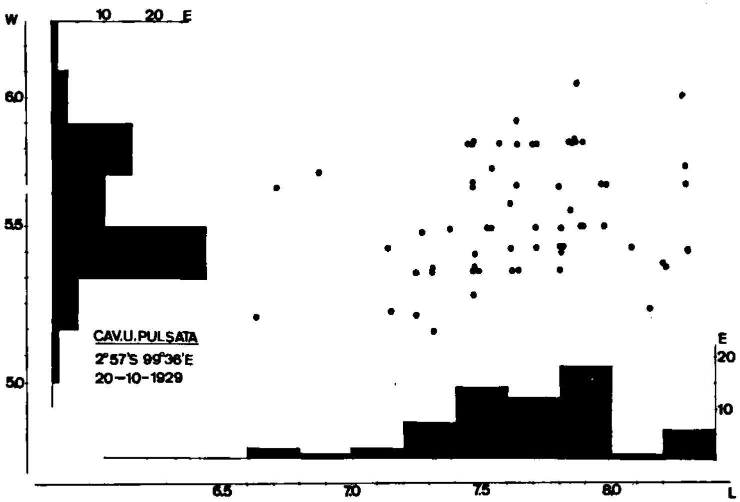


Fig. 41. Graph of shell length and width in *Cavolinia uncinata* forma *pulsata* (Dana Sta. 3860).

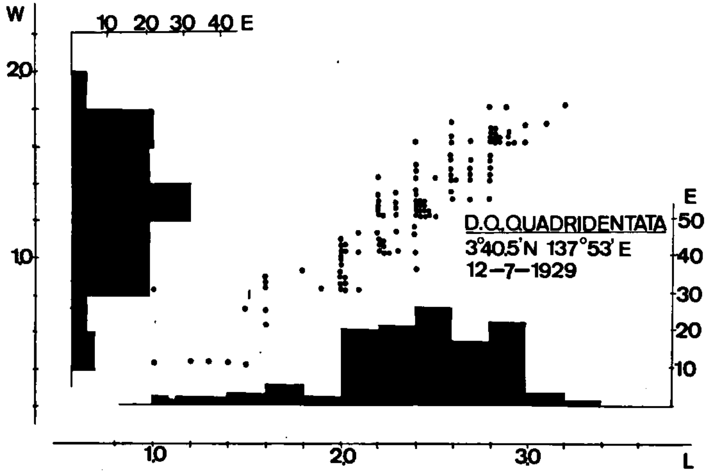


Fig. 42. Graph of shell length and width in juvenile specimens of *Diacria quadridentata* forma *quadridentata* (Dana Sta. 3751. V).

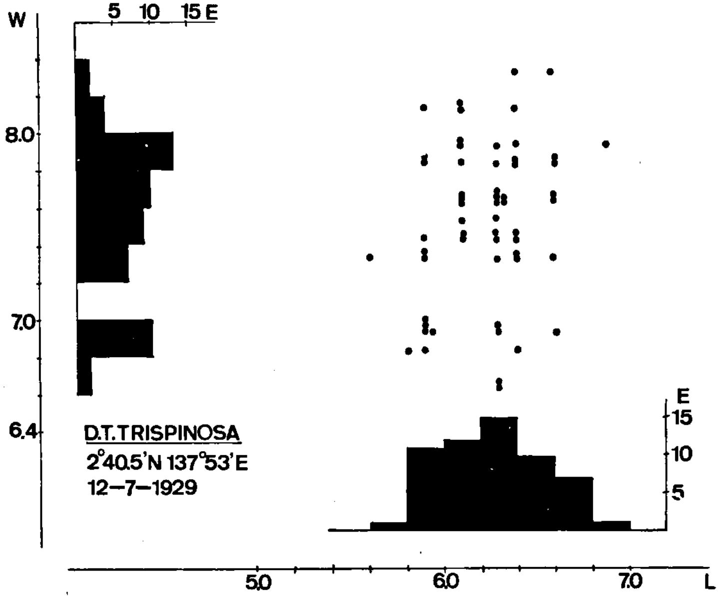


Fig. 43. Graph of shell length and width in *Diacria trispinosa* forma *trispinosa* (Dana Sta. 3751).

First of all it should be mentioned that material of the last species was scarce, only small samples being at my disposal. One may perhaps expect that the juveniles will grow in the same way as in *C. globulosa* so that size distribution in a population of juvenile *C. tridentata* will show a curve of the B2 type. The adults, however, show a curve of the C3 type for the shell length and shell thickness, and a curve of the B2 type for shell width. During metamorphosis the variation in width is thus not altered but that in length and thickness seems to be changed by a process as shown in figs. 27C or G.

The dorsal surface in *C. tridentata* does not bend strongly ventrad so that final growth (after metamorphosis) does increase shell width less than shell length, and shell thickness will increase more than width but less than length. This means that size distribution in adults will resemble mostly that of the juveniles when the width is concerned, which is shown by the B2 type of the curves of width. For the change of a B2 curve into a C3 curve a strong change is

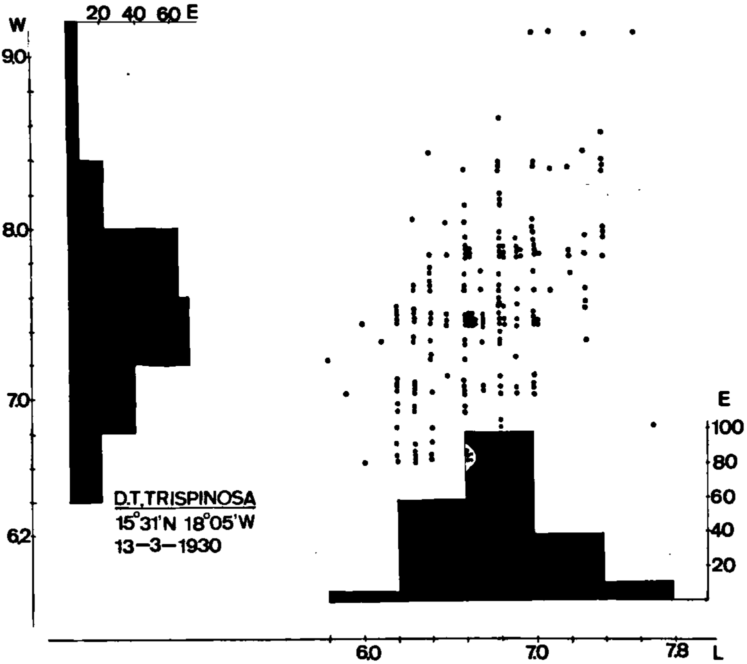


Fig. 44. Graph of shell length and width in *Diacria trispinosa* forma *trispinosa* (Dana Sta. 4006. IV).

needed, so that the stronger process given in fig. 27G seems to fit the case instead of that in fig. 27C. The growth of Cavoliniidae usually shows the curve of size increase as given in fig. 27A, so that it seems more logical to accept the situation as represented in fig. 27G rather than that in fig. 27C for the exceptional case of *C. tridentata*. The curves of *Cuvierina columnella* (figs. 14-17) are very problematic because those for shell-length distribution show always two or more tops at distances of about 0.3-0.5 mm. The shell width variation shows only one top. Curves with more tops may indicate that either genetically different groups occur together or that different age classes are represented in the population. There is no indication for the occurrence of genetically different groups in the population of e.g., figs. 14, 15, and 17, so that one may assume that the tops represent age classes. Comparing the tops with growth data of *Clio pyramidata* (Van der Spoel, 1969c, fig. 8) one finds that the

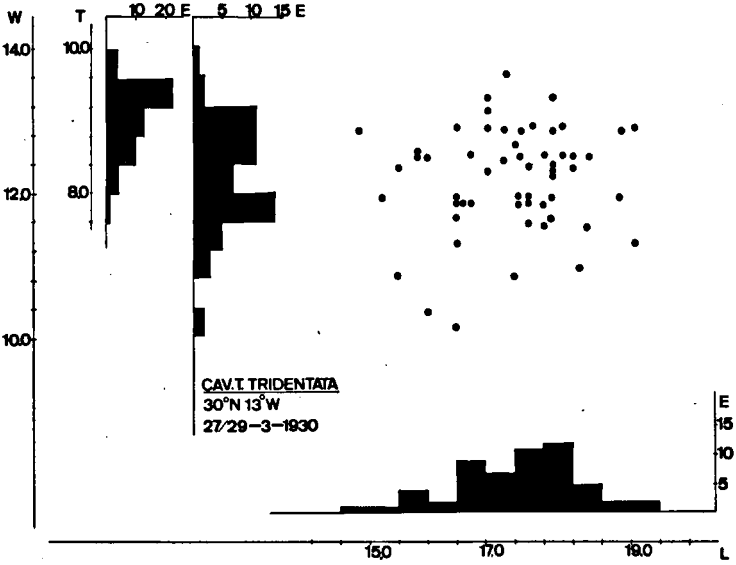


Fig. 45. Graph of shell length, width and thickness in *Cavolinia tridentata* forma *tridentata* (Dana Sta. 4017/4018).

distance between two tops may represent the increase by growth during one day. In figs. 19 and 20 growth lines are found at mutual distances of 0.4 mm, which fact supports the hypothesis that after metamorphosis growth proceeds intermittently as is known for *Clio*. The tops then will represent day classes. This measurable size increase of the permanent shell is not found in other Cavoliniinae. Another explanation for the tops is that growth stop did not occur in the whole population or brood at the same time, but that a group of specimens stopped growing at one day, the next group at the next day, etc.

Variation in width of the shell results in curves of size distribution comparable with the B2 type; length variation curves also show a tendency towards curves of the B2 type. This would indicate that smaller juveniles grow slower than larger ones. In regard to this *Cuvierina* is comparable with most species of *Cavolinia*. The abrupt growth-stop seems, however, absent and in one and the same population specimens are found which obviously have stopped growing temporarily or altogether at different days. The fact that

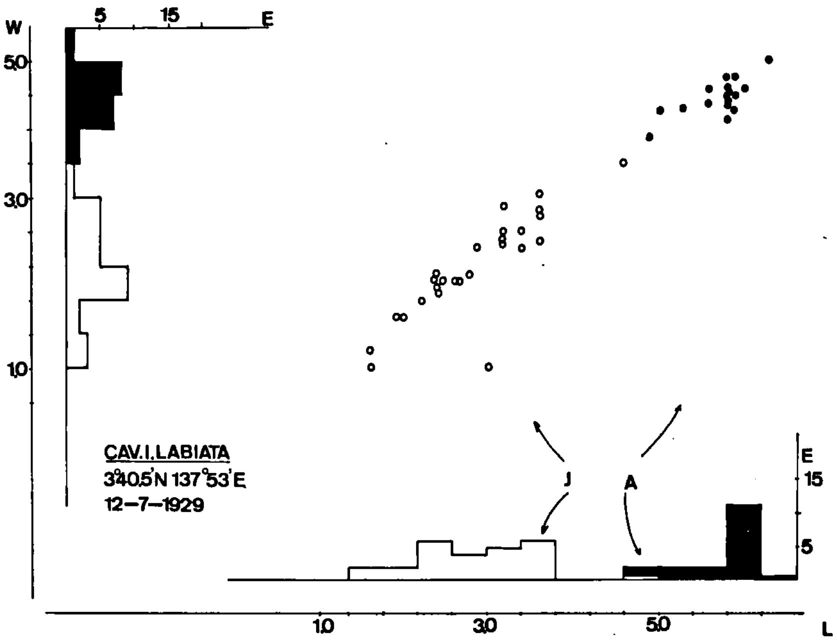


Fig. 46. Graph of shell length and width in juvenile (white) and adult (black) *Cavolinia inflexa* forma *labiata* (Dana Sta. 3751).

the curves of shell-width never show more than one top proves growth of the juveniles not to be the reason for the occurrence of more than one top, since different size groups in the juveniles would be easier discovered in the width variation of the adults than in the length variation. The shell width is largely determined by growth of the juveniles, while shell length is determined by the growth during, or directly after, the metamorphosis during the minute stage.

An example of double-topped frequency distribution of shell width and shell length is found in *Diacria quadridentata* (fig. 35). In the population represented in fig. 35, however, two formae are found. In fig. 34 (bottom) the shell length of the specimens is plotted against the width of the caudal spine mark. The caudal spine mark differs in size in the different formae of *D. quadridentata* (Van der Spoel, 1968a). The frequency distribution of shell length is given in separate histograms for the formae *quadridentata* and *orbignyi* and for specimens representing intermediates with regard to the

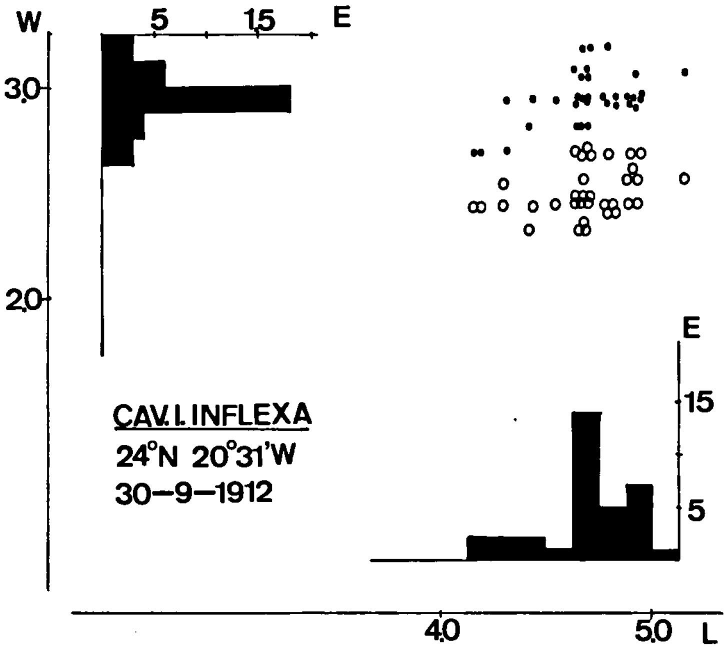


Fig. 47. Graph of shell length and width (black circles) or caudal spine length (open circles) in *Cavolinia inflexa* forma *inflexa* (Dana Sta. 662).

spine mark. Separation is based on the difference in diameter of the caudal spine mark.

Skinny stages are only found in *Cuvierina columnella* and *Cavolinia longirostris* (Van der Spoel, 1967) while in all other Cavoliniinae minute stages are found after the juvenile stage. This phenomenon coincides with the fact that shell length variation is quite marked in these two species. The skinny stage seems to permit growth of the permanent shell after the juvenile phase of the soft parts. This growth will necessarily result in a larger variation of the shell size than growth, which is limited by the abrupt process of metamorphosis, such as is known in *Diacria* and most *Cavolinia* species.

As far as I know skinny or minute stages have never been found in *Cavolinia inflexa* (figs. 46-51). In contrast to all other *Cavolinia* species size distribution here will be determined by the growth of the juveniles only. Size distribution for shell length and shell width

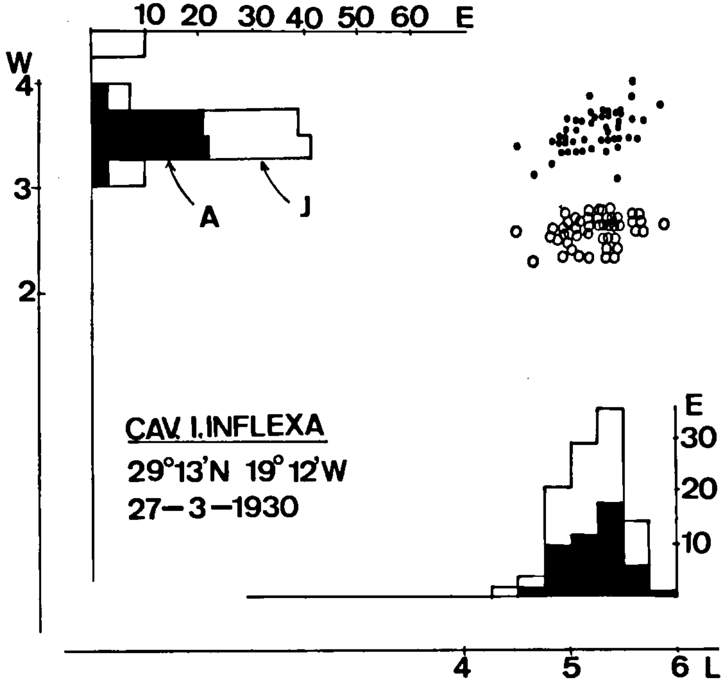


Fig. 48. Graph of shell length and width (black circles) or caudal spine length (open circles) in *Cavolinia inflexa* forma *inflexa* (Dana Sta. 4017).

results in curves of the C3 type. In analogy to what has been said regarding *Clio pyramidata* one may conclude that the larger the specimens are, the slower they will be growing. The curves for *Cavolinia inflexa* forma *labiata* (fig. 46) are based on only a small number of specimens, but there is an indication that the material represents two broods because specimens of 3.8-4.6 mm in length are absent. In the case of only one brood one has to suppose a very fast growth between 3.8 and 4.6 mm for which no indication in the biology of the species is found.

In figs. 47-50 populations of only adults of *C. inflexa* forma *inflexa* are represented; the relation shell length/caudal spine length is also given in these figures. It is obvious that the populations at 24°N 20°31'W, 29°13'N 19°12'W, and 10°16'N 40°42'W are

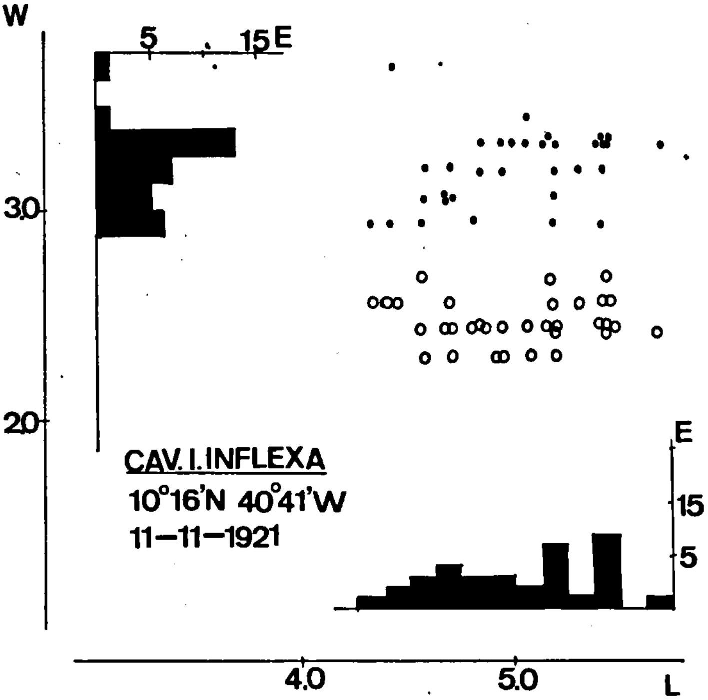


Fig. 49. Graph of shell length and width (black circles) or caudal spine length (open circles) in *Cavolinia inflexa* forma *inflexa* (Dana Sta. 1166).

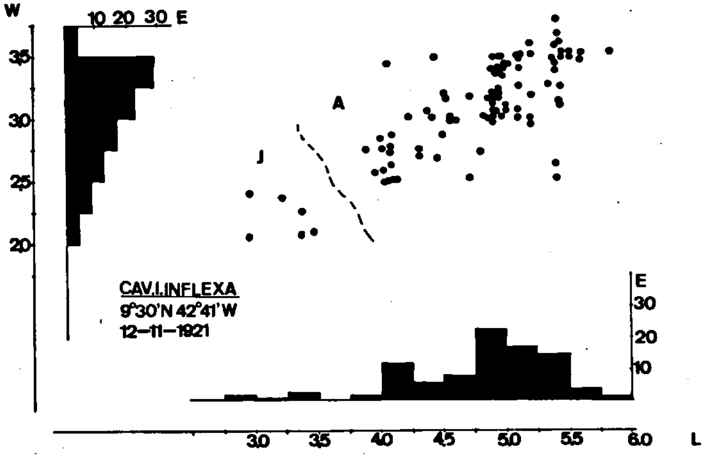


Fig. 50. Graph of shell length and width in *Cavolinia inflexa* forma *inflexa* (Dana Sta. 1168).

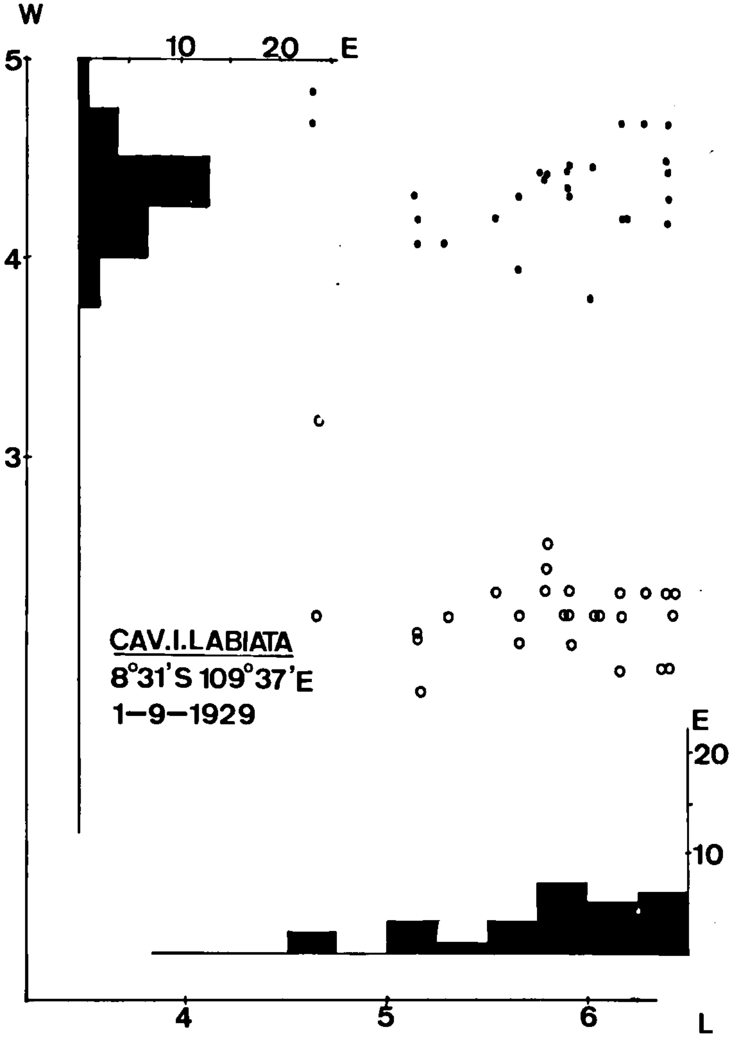


Fig. 51. Graph of shell length and width (black circles) or caudal spine length (open circles) in *Cavolinia inflexa* forma *labiata* (Dana Sta. 3805b).

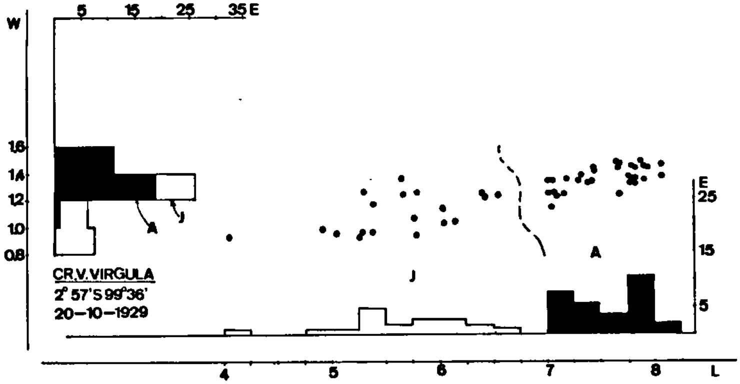


Fig. 52. Graph of shell length and width in *Creseis virgula* forma *virgula* (Dana Sta. 3860).

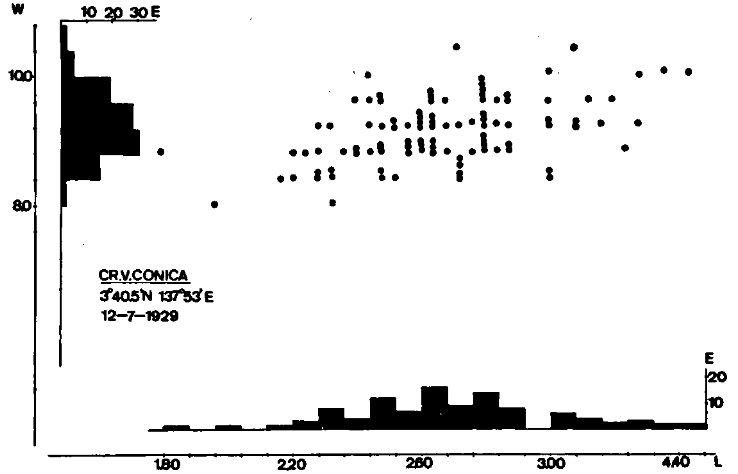


Fig. 53. Graph of shell length and width in *Creseis virgula* forma *conica* (Dana Sta. 3751. IV).

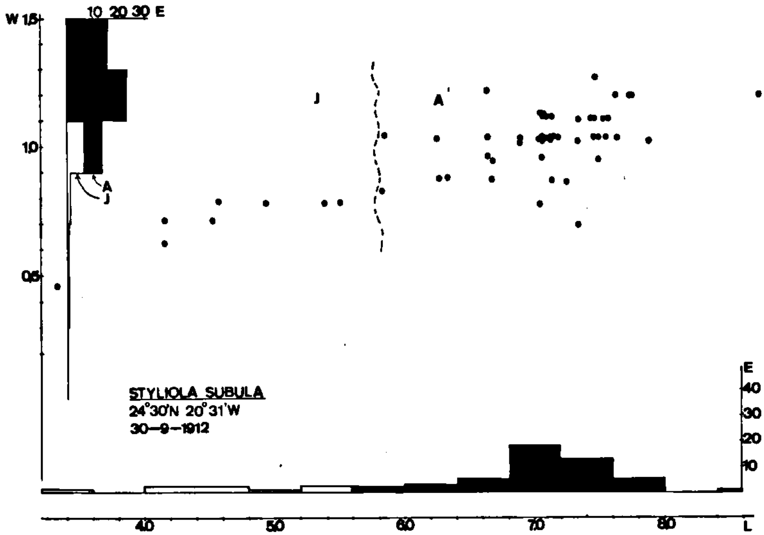


Fig. 54. Graph of shell length and width in *Styliola subula* (Dana Sta. 662).

remarkably identical in size composition and that the specimens are of the same size at different depths (fig. 48).

Size distribution for *C. inflexa* forma *labiata* is given in fig. 51. The difference of the shell width and the relation of shell length/caudal spine length in this forma with regard to the forma *inflexa* is quite obvious here.

Clio pyramidata (figs. 8, 9, and 29), *Creseis virgula* (figs. 52-53), and *Styliola subula* (fig. 54) are species without a growth stop. The length variation shows curves of the C3 type in all figures which proves that large specimens grow slower than smaller ones. The width variation also shows the C3 type, except for the population of *Clio pyramidata* in figs. 8 and 9, and of *Creseis virgula* forma *conica* in fig. 53, where curves of the B2 type represent width variation.

The juveniles of *Clio pyramidata* show curves of the B2 type for width variation. This is evident because growth of the lateral spines is most important in large specimens as the spines develop rather quickly when the shell is already comparatively large. Probably the adults show the same variability because growth does not change much in shell width variation after the juvenile stage. However, the histogram of fig. 29 cannot be explained because width variation shows a normal C3 type in its curve.

The B2 type of width variation curves in *Creseis virgula* forma *conica* may be explained in the same way as has been done for *Clio*, though further investigations are needed.

SUMMARY

The difference in size variations of different populations of *Diacria trispinosa, Clio pyramidata, D. quadridentata, Cuvierina columnella, Cavolinia uncinata*, and *C. longirostris* is described. The latitudinal variation in size is demonstrated. The influence of juvenile, minute, skinny, and adult stages on the size variation in a population is discussed. *"Hyalaea limbata"*, described by D'Orbigny in 1836, is re-described as *Cavolinia longirostris* forma *limbata*. In *Cuvierina columnella* the forma *atlantica* is described as new. The formae *limbata* and *atlantica* are the largest forms in the respective species. Growth in length of *Cuvierina columnella* and growth in thickness in *Cavolinia gibbosa* and *C. globulosa* are also discussed.

Size frequency distribution in populations of *Cavolinia globulosa, Clio pyramidata, Diacria trispinosa, D. quadridentata, Cavolinia longirostris, C. uncinata, C. tridentata, Cuvierina columnella, Cavolinia inflexa, Creseis virgula*, and *Styliola subula*, and the influence which is responsible for the skewing to the right or to the left of the various curves are explained. The phenomenon of shell metamorphosis and the growth type of the juveniles are also discussed.

SAMENVATTING

De variabiliteit van de schelp van enkele Pteropoda is besproken. De afmetingen van de schelp blijken afhankelijk te zijn van oecologische en genetische factoren. De verschillen in schelpgrootte bij dieren die gevangen werden op verschillende breedten in de Atlantische Oceaan bleken aantoonbaar. Dit gedeeltelijk zeker oecologisch (fenotypisch) bepaalde verschijnsel van "latitudinal variation" is o.a. aangetoond door *Diacria trispinosa* (fig. 1). De grootste schelpen komen voor bij dieren uit de noordelijkste gedeelten van hun verspreidingsgebied; in gebieden rond 30°N bestaan de populaties uit dieren met de kleinste schelpen, in tropische wateren komen dieren voor met schelpen van gemiddelde grootte terwijl in equatoriale gebieden ook weer kleine schelpen worden gevonden. Aandacht werd besteed aan de verschillen in schelpgrootte die optreden tussen populaties van *Diacria trispinosa, D. quadridentata, Clio pyramidata, Cuvierina columnella, Cavolinia uncinata* en *C. longirostris*. Naast deze fenotypische verschillen zijn verschillen van genetische aard beschreven tussen de formae van *Cavolinia longirostris* en *Cuvierina columnella*. Binnen de soort *Cavolinia longirostris* werd de forma *limbata* opnieuw beschreven; deze was echter reeds in 1836 door d'Orbigny als soort beschreven maar sindsdien niet meer herkend. In *Cuvierina columnella* werd de forma *atlantica* als nieuw beschreven. Beide formae zijn hoofdzakelijk

op morfometrische kenmerken te onderscheiden; het zijn de grootste formae van beide soorten. Het karakter van de variatie binnen een populatie is beschreven voor de soorten *Cavolinia globulosa, C. longirostris, C. uncinata, C. tridentata, C. inflexa, Diacria trispinosa, D. quadridentata, Cuvierina columnella, Clio pyramidata, Creseis virgula* en *Styliola subula*. De invloed van het voorkomen van het jeugdstadium, het dwergstadium en het volwassen stadium op het beeld van de variatie binnen een populatie is beschreven. Het blijkt dat de groeisnelheid en de wijze waarop de schelpgroei stopt bij het volwassen worden van het dier, van veel invloed is op de variatie van de grootte binnen een populatie. Aan het beeld van de variatie, uitgezet als curve of histogram, kan men zelfs reconstrueren welke verschijnselen optreden tijdens het volwassen worden en de groei van de dieren van een bepaalde soort.

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